AVIAN DIVERSITY IN RELATION TO INDIGENOUS TREES

Thesis

Submitted to the Punjab Agricultural University
in partial fulfillment of the requirements
for the degree of

MASTER OF SCIENCE
in
ZOOLOGY
(Minor Subject: Agronomy)

By

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2018

CERTIFICATE - I

This is to certify that the thesis entitled **"AVIAN DIVERSITY IN RELATION TO INDIGENOUS TREES"** submitted for the degree of **Master of Science** in the subject of **Zoology** (Minor subject: **Agronomy**) of the Punjab Agricultural University, Ludhiana, is a bonafide research work carried out by **Navdeep Kaur** (**L-2015-BS-291-M**) under my supervision and that no part of this thesis has been submitted for any other degree.

The assistance and help received during the course of investigation have been fully acknowledged.

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CERTIFICATE - II

This is to certify that the dissertation entitled, **"AVIAN DIVERSITY IN RELATION TO INDIGENOUS TREES"** submitted by **Navdeep Kaur** (Admission No. **L-2015-BS-291-M**) to the Punjab Agricultural University, Ludhiana, in partial fulfillment of the requirements for the degree of **M.Sc.,** in the subject of **Zoology** (Minor subject: **Agronomy**) has been approved by the Student's Advisory Committee after an oral examination on the same.

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Acknowledgements

I feel very privileged to express my deep sense of gratitude to "God Almighty" for showing his blessings and helping me throughout period of my study.

Though the debt of learning can never be repaid, it is my sovereign privilege to express my profound sense of gratitude and reverence to my Major Advisor, ***Dr. Manoj Kumar (Asst.Ornithologist)*** *Department of Zoology, PAU, for his ever-willing help, liberal attitude, constructive criticism, proper visualization and rectification of the problems encountered from time to time without which this work could not given its present shape.*

My sincere thanks are to ***Dr. S.S. Hundal,*** *Professor & Head, Department of Zoology for providing necessary facilities required for the present investigation and for her important suggestions.*

I wish to express my warm and sincere thanks to the members of my advisory committee viz. ***Dr. Tejdeep Kaur Kler****, (Senior Ornithologist) Department of Zoology,* ***Dr. Sohan Singh Walia****,(Senior Agronomist) School of Organic Farming and* ***Dr. Neena Singla*** *(Dean PGS nominee), Department of Zoology for their valuable suggestions and comments throughout my research.*

I feel great elation in expressing my thanks to ***Dr. Nisha Vashishat*** *(Assistant Ornithologist), Department of Zoology for her moral support.*

I would like to thank my family. The constant inspiration and guidance kept me focused and motivated. I am grateful to my mother ***Sukhpreet Kaur*** *for giving me the life. I can't express my gratitude for my grandfather* ***S. Lachman Singh*** *in words, whose unconditional love has been my greatest strength. Language and words are too inadequate to express my feelings of indebtness and gratitude to my sister* ***Mandeep Kaur****, brother* ***Deep Davinder, Kuldeep and Rajdeep*** *for their encouragement and loving emotions which enabled me to complete this work. Their constant love and support is sincerely acknowledged. I find no words complimentary enough to acknowledge their love, warmth, encouragement and moral support. "Thanks" is not enough for their contribution.*

I would also like to express my gratitude to all my friends especially, ***Gaggu, Jyoti, Yashika, Kamaljeet, Sandal didi, Sukhpreet didi****,* ***Jass Sidhu*** *and* ***Rajesh bhaiya*** *for their support throughout my study. No choice of words will be suffice to adequately register thanks tothese friends, who always extended a helping hand and gave their best suggestions in my research work, moreover they encouraged and supported me in her own sweet and lovable way during my research work.*

I dedicate my thesis to my parents who encouraged me to take admission in this university.

No words would be sufficient to register thanks to ***Harpal Sir, Rajesh Sir*** *and* ***Manpreet Sir*** *their necessary help in the fields during my research work.*

Assistance and cooperation extended by the non- teaching staff and all the attendants of Zoology Department is whole heartedly acknowledged.

Above all, all could not be mentioned but none is forgotten.

(Navdeep Kaur)

Title of the Thesis	**:**	Avian diversity in relation to indigenous trees
Name of the Student and Admission No.	**:**	Navdeep Kaur (L-2015-BS-291-M)
Major Subject	**:**	Zoology
Minor Subject	**:**	Agronomy
Name and Designation of Major Advisor	**:**	Dr. Manoj Kumar Assistant Orinthologist
Degree to be Awarded	**:**	M.Sc.
Year of award of degree	**:**	2018
Total pages in thesis	**:**	93 + Vita
Name of the University	**:**	Punjab Agricultural University, Ludhiana–141 004, Punjab, India

ABSTRACT

The present study on avian community structure in relation to indigenous trees was conducted at Punjab Agricultural University, Ludhiana (Location I) and village Machaki Mal Singh, Faridkot (Location II). Six different indigenous trees were selected i.e Banyan (*Ficus benghalenesis*), Jamun (*Syzygium cumini*), Mulberry (*Morus alba*), Neem (*Azardirachta indica*), Pipal (*Ficus religiosa*), Sheesham (*Dalbergia sissoo*). A total of 52 species of birds were observed on selected tree speices from April 2016 to March 2017. Cumulative count of birds on all selected trees showed numerical dominance of Common Myna (*Acridotheres tristis*), Rose-ringed Parakeet (*Psittacula krameri*) and House Crow (*Corvus spendens*). Trees under study provided nesting sites for seven bird species i.e. Black Kite (*Milvus migrans*), Cattle Egret (*Bubulcus ibis*), House Crow (*Corvus splendens*), Little Brown Dove (*Streptopelia senegalensis*), Asian Pied Starling (*Sturnus contra*), Oriental Magpie-Robin (*Copsychus saularis*) and Spotted Owlet (*Athene brama*). Five bird species were observed nesting at location I while only two were observed at location II. Selection of nesting site, nesting materials and nesting structures were monitored and studied. Total 14 nests (Four on Pipal tree, 3 on Banyan tree, 2 on Mulberry, 2 on Jamun, 2 on Neem and 1 on Sheesham) were recorded. Out of these, three nests were of Black Kite, 6 of House Crow, 1 of Oriental Magpie-Robin, 1 of Asian Pied Starling, 1 of Little Brown Dove 1 of Spotted Owlet and 1 of Cattle Egret. Breeding of all the 7 bird species was noticed from beginning of April to September. This study suggests that the retention or planting of native trees is an important tool for conserving birds and will provide additional ecosystem services.

Key words: Birds, indigenous trees, abundance, nesting

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Signature of Major Advisor **Signature of the student**

ਖੋਜ ਗ੍ਰੰਥ ਦਾ ਸਿਰਲੇਖ	:	ਸਵਦੇਸ਼ੀ ਦਰੱਖਤਾਂ ਨਾਲ ਸੰਬੰਧ ਰੱਖਣ ਵਾਲੇ ਪੰਛੀਆਂ ਦੀ ਵਿਭਿੰਨਤਾ
ਵਿਦਿਆਰਥੀ ਦਾ ਨਾਂ ਅਤੇ ਦਾਖ਼ਲਾ ਨੰਬਰ	:	ਨਵਦੀਪ ਕੌਰ (ਐੱਲ-2015-ਬੀ.ਐੱਸ-291-ਐੱਮ)
ਮੁੱਖ ਵਿਸ਼ਾ	:	ਜੀਵ ਵਿਗਿਆਨ
ਸਹਿਯੋਗੀ ਵਿਸ਼ਾ	:	ਅਗਰੌਨਮੀ
ਮੁੱਖ ਸਲਾਹਕਾਰ ਦਾ ਨਾਂ ਅਤੇ ਅਹੁੱਦਾ	:	ਡਾ. ਮਨੋਜ ਕੁਮਾਰ ਸਹਾਇਕ ਐਰਨੀਥੋਲੋਜਿਸਟ
ਡਿਗਰੀ	:	ਮਾਸਟਰ ਆਫ਼ ਸਾਇੰਸ
ਡਿਗਰੀ ਨਾਲ ਸਨਮਾਨਿਤ ਕਰਨ ਦਾ ਸਾਲ	:	2018
ਖੋਜ ਪੱਤਰ ਵਿੱਚ ਕੁੱਲ ਪੰਨੇ	:	93+ਵੀਟਾ
ਯੂਨੀਵਰਸਿਟੀ ਦਾ ਨਾਮ	:	ਪੰਜਾਬ ਖੇਤੀਬਾੜੀ ਯੂਨੀਵਰਸਿਟੀ, ਲੁਧਿਆਣਾ - 141004 ਪੰਜਾਬ, ਭਾਰਤ ।

ਸਾਰ-ਅੰਸ਼

ਅਜੋਕੀ ਖੋਜ ਸਵਦੇਸ਼ੀ ਦਰੱਖਤਾਂ ਨਾਲ ਸੰਬੰਧ ਰੱਖਣ ਵਾਲੇ ਪੰਛੀਆਂ ਦੀ ਵਿਭਿੰਨਤਾ ਤੇ ਪੰਜਾਬ ਖੇਤੀਬਾੜੀ ਯੂਨੀਵਰਸਟੀ, ਲੁਧਿਆਣਾ ਅਤੇ ਪਿੰਡ ਮਚਾਕੀ ਮੱਲ ਸਿੰਘ ਵਿਚ ਕੀਤੀ ਗਈ।ਇਸ ਖੋਜ ਲਈ ਛੇ ਸਵਦੇਸ਼ੀ ਦਰਖਤ ਚੁਣੇ ਗਏ; ਬੋਹੜ (ਫਾਇਕਸ ਬੈਂਗਾਲੈਨਸਿਸ), ਜਾਮਨ (ਸਾਈਜ਼ਗੀਅਮ ਕੁਮਿਨੀ), ਤੂਤ (ਮੋਰਸ ਅਲਬਾ), ਨਿੰਮ (ਅਜ਼ਾਰਡੀਰੈਕਟਾ), ਪਿੱਪਲ (ਫਾਇਕਸ ਰੈਲੀਗਿਓਸਾ) ਅਤੇ ਟਾਹਲੀ (ਦਾਲਬਰਜ਼ੀਆ ਸਿਸੂ)। ਅਪ੍ਰੈਲ 2016 ਤੋਂ ਮਾਰਚ 2017 ਤੱਕ ਕੁੱਲ 52 ਪੰਛੀਆਂ ਦੀਆਂ ਪਰਜਾਤੀਆਂ ਦੇਖੀਆਂ ਗਈਆਂ।ਪਰਜਤੀ ਵਿਭਿੰਨਤਾ ਮੁਤਾਬਿਕ ਆਮ ਮੈਨਾ, ਤੋਤਾ ਅਤੇ ਘਰੇਲੂ ਕਾਂ ਵਧ ਦੇਖੇ ਗਏ।ਚੁਣੇ ਗਏ ਸਵਦੇਸ਼ੀ ਦਰਖਤਾਂ ਉੱਤੇ ਸੱਤ ਪੰਛੀ ਪਰਜਾਤੀਆਂ ਦੇ ਆਲ੍ਹਣੇ ਦੇਖਣ ਨੂੰ ਮਿਲੇ ਜਿਵੇਂ ਕਿ ਕਾਲੀ ਇਲ, ਘਰੇਲੂ ਕਾਂ, ਬਦਾਮੀ ਬਗੁਲਾ, ਟੋਟਰੂ, ਡਬੀ ਮੈਨਾ, ਚਿਤਰਾ ਲਮਢੀਂਗ ਅਤੇ ਚੁਗਲ।ਪੰਜ ਪੰਛੀ ਪਰਜਾਤੀਆਂ ਦੇ ਆਲ੍ਹਣੇ ਯੂਨੀਵਰਸਟੀ ਵਿਚ ਦੇਖੇ ਗਏ ਅਤੇ ਦੋ ਪੰਛੀ ਪਰਜਾਤੀਆਂ ਦੇ ਆਲ੍ਹਣੇ ਪਿੰਡ ਵਿਚ ਦੇਖੇ ਗਏ।ਆਲ੍ਹਣੇ ਦਾ ਵਿਹਾਰ ਅਤੇ ਵਰਤੇ ਜਾਣ ਵਾਲੇ ਪਦਾਰਥ ਦੀ ਜਾਂਚ ਕੀਤੀ ਗਈ।ਕੁਲ 14 ਆਲ੍ਹਣੇ ਮਿਲੇ ਜਿਹਨਾਂ ਵਿਚੋਂ 4 ਪਿੱਪਲ, 3 ਬੋਹੜ, 2 ਤੂਤ, 2 ਜਾਮਨ, 2 ਨਿੰਮ ਅਤੇ 1 ਟਾਹਲੀ ਤੇ ਸਨ।ਇਹਨਾਂ ਵਿਚੋਂ 3 ਆਲ੍ਹਣੇ ਕਾਲੀ ਇਲ ਦੇ ਸਨ, 6 ਘਰੇਲੂ ਕਾਂ, 1 ਡਬੀ ਮੈਨਾ ਦਾ, 1 ਚਿਤਰਾ ਲਮਢੀਂਗ, 1 ਟੋਟਰੂ, 1 ਚੁਗਲ ਅਤੇ 1 ਬਦਾਮੀ ਬਗੁਲਾ ਦੇ ਸਨ।ਸਵਦੇਸ਼ੀ ਦਰਖਤਾਂ ਪੰਛੀਆਂ ਦੀ ਸੰਖਿਆ ਨੂੰ ਪ੍ਰਭਾਵਿਤ ਕਰਦੇ ਹਨ, ਇਸ ਲਈ ਇਹ ਖੋਜ ਸਵਦੇਸ਼ੀ ਦਰਖਤ ਲਾਉਣ ਦੀ ਪ੍ਰੇਰਣਾ ਦਿੰਦੀ ਹੈ।

ਮੁੱਖ ਸ਼ਬਦ: ਖਾਸ ਸ਼ਬਦ: ਪੰਛੀ, ਸਵਦੇਸ਼ੀ ਦਰੱਖਤ, ਸੰਖਿਆ, ਆਲ੍ਹਣੇ

ਮੁੱਖ ਸਲਾਹਕਾਰ ਦੇ ਹਸਤਾਖਰ **ਵਿੱਦਿਆਰਥੀ ਦੇ ਹਸਤਾਖਰ**

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CHAPTER I

INTRODUCTION

There are around 1314 species of avifauna in India (Oleti 2010). About 328 species of bird fauna are found in Punjab (Jerath and Chadha 2006). International Union for Conservation of Nature (IUCN) claims that bird community faces high threat to extinction. Out of more than 9000 species of living birds, almost 150 are found to be extinct after the human arrival (Sibley 2001).

Birds show an intimate relationship with trees as they are used by them for various purposes, i.e. for shelter, foraging, roosting, courtship and breeding. In return birds are also advantageous for trees as their flowers are cross pollinated and seeds are dispersed by birds (Mathew *et al* 1983). The trees offer a habitat for birds and the abundance of birds is directly related to the presence of worthy habitat.

Distribution, abundance, richness and diversity of bird fauna is affected by the vegetation structure in different bird habitats (Augenfeld *et al* 2008). Essential foraging, roosting, nesting requirements and other necessities for nurturing brood are fulfilled by vegetation type, vertical stratification and canopy complexity provided (Augenfeld *et al* 2008). Habitat loss, destruction and degradation are intimidating remarks to richness and diversity of avifauna.

Specific habitat requirements shown by many bird species reveals that there is a close relationship between the vegetation and the avian community composition, and even subtle changes in forest structure can show noticeable effects on bird community (Ansell *et al* 2011). Reduction in canopy cover exhibits a frequent decline in bird diversity and species richness (Matlock and Edwards 2006). The finding of MacArthur and MacArthur (1961) were the first evidence that says more layered vegetation supports greater bird diversity offering more foraging niches. Birds and mammals use dead and mature trees for roosting, foraging, drumming, and perching (Styring and Ickes 2001).

Most of the bird species rely on different types of forest ecosystems for survival. Different tree species permit for different opportunities for foraging, nesting and shelter (Lee and Rotteberry 2005). Widely varying habitats are offered by different forest ecosystems because of differing tree species. For example, it has been suggested by Abrams and Rodewald (2002) that oak trees may supply more foraging opportunities for insectivorous birds than maple trees. According to Ali *et al* (2013) population of feral pigeons in urban areas shows definite relationship with ecological requirements like roosting sites, nesting sites, food and water points.

Avian community structure on a particular tree species dependent upon the characteristics of the trees as well as on the various features of the habitat in vicinity (Faanes

1987). Fulfillment of specific requirements of bird species in a habitat also decides its species richness of that area. Every bird has a specific niche where it feeds (Ford *et al* 1986). The foraging niche differs not only between species but may also differ between sexes.

The proportion of food afforded by a tree also affects the bird community. For example *Ficus* trees provide alternative food to most of the frugivores and many omnivorous birds. About 60 bird species have been recorded feeding on figs in Malaysian lowland rain forest (Lambert 1989).

Exposed perches of trees are used by birds like Drongos and Kingfishers to monitor the moving prey (Ali and Ripley 1983). Generally, Crows consume different food stuffs brought from surrounding areas while perching on trees as they consider it safer place for feeding. Tall and dominant trees in the surrounding habitat of fruit orchards are used by parakeets as perching sites and then they fly from there for consuming ripe fruits from orchard trees. Preference for roosting varies as some bird species chose the bare trees while others prefer the ones with dense foliage.

Bird community is very closely associated with trees for its nesting requirements. Even aquatic birds like Egrets, Herons and Waterhens which otherwise prefer to live around water for their food requirements, make use of trees in the neighborhood for breeding. Tall and old trees are preferred nesting sites of large birds like hawks and eagles. Old trees are also preferred by cavity nesters especially Woodpeckers (Land *et al* 1989). Birds in urban areas show tendency of selecting higher site for their nests and also in areas with lower disturbance because nests situated in lower parts of trees are more prone to risks of predation and disturbance by humans than nests situated in higher parts of trees (Dhindsa *et al* 1989).

Agro-ecosystem is one of the habitats that also determine the population sizes of the biodiversity that can be maintained in that particular area. Birds constitute an important component in agro-ecosystems and biodiversity. Birds are gaining more and more attention and are better understood in biodiversity in many respects than any other major group of organisms because they grab more extreme interest of humans, are easy to observe and not too difficult to identify (Bruford 2002). Agricultural production is highly influenced by services such as pest control, pollination and soil fertility, in which birds play a title role by providing these important ecosystem services. Birds that feed on harmful insects and other pests in agro-ecosystems proving to be beneficial to agriculturists. No doubt birds play a beneficial role in agro-ecosystem but in return they are provided with highly predictable source of food. Tscharntke *et al* (2008) reported that habitat and diet breadth of agricultural bird species is greater than forest species

The variation in abundance and diversity of insectivorous bird communities in these agro-ecosystems is subjected to the availability of variety of crops, safety and number of nesting sites and density of perching trees. The insectivorous birds are the natural controllers

of insect predation in agricultural ecosystem (Mehta *et al* 2010).

Scientists claim that birds are the excellent indicators of healthy biodiversity (Sekercioglu 2006). For example, Forest birds play a crucial role in regulating forest trophic chains at the predation level (predation of insects, small mammals, etc.) and, for instance, frugivorous species of bird fauna play an important role by dispersing seeds of different plants in different habitats (Herrera 1985).

Vegetation cover of a particular location affects the abundance and diversity of avian community (Nikolov 2009) and structural components of a forest such as shrubs and graminoids are associated with canopy openness (Smith *et al* 2008). Native tree species that allow more penetration of light, that increases understory vegetation cover, which may in turn serve more nesting-sites and food sources for birds (Quine *et al* 2007), thus supporting higher number of species proving that the additional tree species itself and the secondary effect that the mix of tree species has on forest understory vegetation structure may therefore both influence bird community structure.

According to Diaz (2006), using a native tree species as a secondary mix species in a non-native coniferous plantation may mimic a more natural system and permit bird species that prefer both the primary and secondary plantation tree species to utilize the plantation. There may be increase in food availability for birds with the addition of a native tree species (Hartley 2002), as the number of invertebrate species that a tree hosts may be related to the duration of time the tree has been present in a region (Kennedy and Southwood 1984).

Trees with large diameter and branches welcome more birds and their offspring (Bunnell 2013). Snags and old trees are also preferred by few species for foraging. For example, presence of bark beetles in recently decayed dead wood attracts the three-toed woodpecker for forages on snags (Grove 2001). Three toes woodpecker prefer only recently dead or dying trees because after a certain period, the tree gets unsuitable for the insects because of advanced decaying (Coulson and Witter 1984). Many studies show that these insects are major part of diet of different bird species (Imbeau *et al* 2014).

A study conducted by French *et al* (2005) on nectar production and visitation of nectar-feeding birds to native and exotic plant species in Australia. But birds show slightly higher rate of visiting to native plant species than exotic

That openness may affect non-crop vegetation, which in turn influences bird communities and Wilson *et al* (2010), suggests that forest management has an important role to play in maximizing the utility of plantations for birds, as thinning increases light transmittance through a coniferous canopy.

Abundance of different bird species in gardens of suburban areas of may get affected by the floristics and structure of these areas (Germaine *et al* 1998). The structural composition of gardens influence the distribution of native avifauna, as the foraging activities of native

avian community are observed more frequently among native plants than among exotic ones (French *et al* 2004)

Birds show alterations in their patterns of using habitat and in their foraging behavior during different seasons (Lewke 1982). However, most of the investigations have mainly emphasized on parameters of landscape and habitat structure during the breeding seasons, and barely at all on the winter season. Insufficient studies are available that cross- examined that whether the factors ruling the aggregation and abundance of local resident bird fauna remain the same or alters throughout the year (Murgui 2010). For interpreting the significance of habitat bird fauna, it basal point to scan its signification on the basis of the existence and richness of species that occur there in different seasons. Along with habitat structure composition and species richness of avian communities is also affected by abiotic factors such as temperature and precipitation; these are directly allied to primary productivity, and have been widely studied in different periods of the year (Honkanen *et al* 2010).

Other factors that decide the importance of site include threat status, breeding status, vulnerability through congregations and the proportion of the total population of each species that occur at the site (Heath and Evans 2002). The status and nature of these species also need to be taken into account.

Migratory birds are influenced by the presence of abundant assets and distribution of individuals in particular location. Migratory behavior in birds permits bird community to harvest seasonal productive outputs during their migration through different routes (Alerstam 1990). This means that resource availability is tracked twice a year by migratory birds, when settling in breeding and wintering grounds.

Certain workers claim that most of the birds are territorial breeders, which probably prevent newcoming conspecifics from settling for breeding once a given density threshold is passed (Pulliam & Danielson 1991). The resulting territorial competition could lead to decrease in resource availability between resident and migratory bird populations (Shochat *et al* 2002). However, in winters much more variation is observed in social behaviours . Many birds maintain territorial behaviour over winter (Telleri´a *et al* 2001), but many others behave like wanderers which track resources across different habitat stretches (Levey and Stiles 1992).

According to Robinson *et al* (2010) creation of roads and plantation of exotic or generalist plant species deteriorate and fragment interior forest by competing with interior forest. Species addicted to interior forest environment are easily affected by the creation of roads, which decreases their foraging sources and shelter probabilities (Robinson *et al* 2010). Vegetation contributes to the framework for terrestrial bird habitats and provides lead that guide for selection habitat (Lee and Rotenberry 2005), as well as nourishment and substratum required for shelter, foraging and breeding (Robinson and Holmes 1984).

According to Garcia *et al* (2008), High nesting densities offered by habitat structure minimize the loss of predatism. Prey detectability and accessibility by birds is influenced by the abundance and distribution of prey and the foliage structure, which varies for different tree species (Holmes & Schultz 1988). Thus, the prey availability for each bird species must be determined separately for each tree species. Since different tree species provide different foraging opportunities for birds, tree species composition within a forest should influence bird species composition and diversity (Holmes & Schultz 1988). Prey abundance for birds varies among tree species and changes temporally during the breeding season (Murakami 1998).

Composition of different plant varieties ion a habitat may also affect the quality of habitat for some animal taxa. The densities of generalist frugivores is affected by the abundance of fleshy fruits available to them (Stevenson 2001), and few taxa such as species of Ficus and palm may be demanding resources of food by different avian species during periods of food scarcity (Forget *et al* 1994).

Bird composition in degraded habitats depends upon the extent to which the naturally occurring species in the forest can adapt to persist in a modified environment (Oostra *et al* 2008).

Invasion of exotic plant species into low herbaceous vegetation have various effects on existing bird communities. While invasions of grass species into established grassland communities shows alterations in the relative population sizes of terrestrial invertebrate groups without affecting the existing passerine bird community (Kennedy *et al* 2009). Other studies have shown that any alteration in vegetation structure and subsequent decline in habitat quality affects the bird community (Fleishman *et al* 2003). This is particularly true for specialist bird species (Ma *et al* 2011) and those foraging on or near the ground (Flanders *et al* 2006).

As a consequence of the invasion of exotic species in the urbanized areas, the native species are lost leading to biological homogenization which poses a threat to the biotic uniqueness of the local ecosystems (Mc Kinney 2005).

Disturbance and fragmentation directly affects the vegetation, such as their distribution and fruit crop characteristics, may affect the foraging behavior of seed-dispersing birds (Korine *et al* 2000). Urbanization and industrialization is a cause for deteriorating tree cover which is main source of accommodation for bird fauna (Gregory *et al* 2004).

The depletion of old-tree cover is particularly troublesome for bird fauna since old trees account to be an important substrate for nesting in the form of dense canopy or cavities and in certain cases foraging. Few scientists claim that trees are suitable for nesting unlikely after a particular age, for example in oaks, hollows are observed developing in trees older than 150 years. Actually, Fungi development starts in a tree at late life stage which leads to decaying forming cavities in trees (Bunnell 2013).

Basic information regarding causes of population fluctuation is collected by monitoring the abundance of birds, preference for habitat and correlationship between species abundance and habitat. Afterwards, this information proves to be beneficial in conservation and management of vulnerable and endangered bird species.

Objectives of study

- To study the association of bird diversity in relation to indigenous trees.
- To study the nesting behaviour on indigenous trees by different birds species.

CHAPTER II

REVIEW OF LITERATURE

An ancient evolutionary history of birds dates back to more than 150 million years (Ali 2002, Sekercioglu 2006). Bird community forms an integral component in an ecosystem and need to be conserved by preserving their habitats which essentially requires the assessment of birds as a prerequisite step (Raman *et al* 2005, Sultana *et al* 2007). Various factors decide the distribution of birds in a particular area which generally includes availability of suitable food, roosting and nesting sites (Aggarwal *et al* 2008). Even a single ecosystem is used differently by different species (Cintra and Naka 2012).

Birds have very close association with trees. Leaving aside birds of prey and some others, almost all birds use some component of trees, for example for foraging, roosting, perching etc. Fresh foliage, buds, fruits, flowers and other nectar are generally consumed by different bird species. Insectivorous birds find large number of insects from different parts of trees (Dickson *et al* 1979)

In all of the habitats, variables such as foliage height, connectivity, heterogeneity and vegetation cover can all have influence on avian abundance and diversity (Gabbe *et al* 2002, Goetz *et al* 2007).

2.1 Community structure

The concept of community structure in birds was first introduced by Giller (1984) and characterized by an interactive assemblage of various species within a particular geographical area (Kormondy 2004). Competitive interactions along with independent ecological functions played an important role in structuring the bird communities, which incorporated identification of species richness, species diversity and species evenness or equitability (Shochat *et al* 2004). A perusal of the relevant literature unfolded that significant work has been carried out on the community structure of the birds in the world. Starting from MacArthur and MacArthur (1961), studies on avian communities proved that heterogeneity in habitat was an important determinant of avian diversity (Moser *et al* 1990) revealed that birds were generally sensitive to habitat alteration. The abundance and structure of bird communities were determined mostly by the type of vegetation cover (Rotenberry 1985) and food availability (Sabo 1980). Few other workers also stated that species diversity and richness has been linked to habitat selection and avian populations and communities are influenced by the type of the habitat (Terborgh *et al* 1990).

Growth stage of habitat structure can have a profound effect on bird assemblages (Holmes & Sherry 2001). Many forest bird species depend on specific habitat features associated with stand age (DeGraaf & Yamasaki 2003) or age of individual trees (Giese & Cuthbert 2003).

The association between vegetation density and species diversity has been correlated with availability of food and foraging niche spaces (MacArthur *et al* 1966). However, few workers hypothesized that birds' distribution was also influenced by the presence of suitable nesting sites. Differences in requirement among bird species have caused specificity on habitat requirement (Buckley and Freckleton 2010).

2.1.1 Foraging

Different ecosystems offer a wide variation in habitat structure because of different tree species. According to Kler *et al* (2015) the garden areas sustain a high proportion of native shrubs which can provide cover and insects to foraging birds. Insects and grubs living in understory vegetation provide more foraging opportunities for birds which may increases number of birds and bird species.

Vegetation composition and habitat structure around the growth site of a particular fruiting tree affect the feeding behaviour of birds, by determining food distribution and cover sites (Nogales *et al* 1999). Eleven species of birds were found interacting with the fruiting trees of *Syzygium cumini* in the Soppinabetta forests of Sringeri. Of these, nine species were frugivorous and two were insectivorous. Red-Whiskered Bulbul (*Pycnonotus jocosus*), Blossom-Headed Parakeet (*Psittacula roseate*), White-Cheeked Barbet (*Megalaima viridis*), Oriental White-Eye (*Zosterops palpebrosus*), Crimson-Backed Sunbird (*Nectarinia minima*), Yellow-Browed Bulbul (*Iole indica*), Purple-Rumped Sunbird (*Nectarinia zeylonica*), Common Myna (*Acridotheres tristis*) and Coppersmith Barbet (*Megalaima haemacephala*) were the frugivorous birds. Among them, the first five species were commonly encountered on all selected fruiting trees. The rest four species were occasional visitors. Golden-Fronted Leafbird (*Chloropsis aurifrons*) and Blue-Winged Leafbird (*Chloropsis cochinchinensis*) were insectivorous birds frequently seen in the foliage of *S. cumini*.

Oaks are considered as keystone species for their important role in maintaining biodiversity in North American forests (McShea *et al* 2007). Many breeding birds and some mammal species are more common in oak dominated than maple dominated forests, due to greater availability of resources e.g., acorn mast, arthropods and cavities (Rodewald and Abrams 2002, Rodewald 2003). Moreover, oaks are found to support higher Lepidopteran richness than other tree species (Tallamy and Shropshire 2009) which is an important foraging resource for migratory songbirds. Aggarwal *et al* (2008) in their investigations on community structure of birds in Nandini wildlife Sanctuary in Jammu and Kashmir estimated the community structure by line transect method, and they recorded 75 species, out of which 23 species were insectivorous, 10 granivorous, 3 omnivorous, 6 frugivorous, 23 species used more than one feeding guilds. Maheswaran (2001) investigated the effect of habitat alteration on the avifauna of the Western Ghats. Bird community in agricultural lands was characterized by over dominance of only a few granivorous and omnivorous species while the rest of

species were represented in very small numbers (Toor *et al* 1986).

According to Dhadse *et al* 2009, Development of green belt and water bodies in urban areas potentially shifted the structure of bird community from insectivorous and granivorous to piscivorous.

A large number of different species of birds are attracted by all fruiting trees, including both cultivated and wild, during fruiting season. Birds like Bulbuls, Cuckoos, Orioles, Green pigeons etc. are abundant on all *Ficus* trees especially when fruit is ripe. *Ficus* trees play an important role in survival of frugivorous birds (Lambert 1989).

2.1.2 Breeding

During the breeding season, birds spatially restrict their mating to a central place due to time and energy constraints imposed by incubation and chick rearing duties. Thus, breeding birds show marked habitat preferences in relation to vegetation structure. Specifically, structural complexity of vegetation (tree maturity in forest environments) seems to be the most important attribute determining species richness and diversity at the local scale (Hinsley *et al* 2009). In contrast, during the winter period, when food resources are much scarcer and weather conditions unpredictable, birds adopt a vagabonding lifestyle exploring a greater variety of habitats over larger areas to track the spatiotemporal distribution of food availability (Wiktander *et al* 2001). From this perspective, in determining bird distribution at local scales it should be expected that vegetation structure loses importance in winter with respect to the breeding season. Moreover, the ordered gains and losses of species in assemblages, or nestedness, is hypothesized to decrease in periods of high mobility and relaxed habitat preferences, as is the case during wintertime (Murgui 2010).

A nest is a platform for birds, specifically, to hold eggs, where they incubate their eggs and raise their young-ones during breeding period (Natarajan 1997, Ali 2002). On the basis of nesting birds are grouped into two categories *viz.,* open nesters and cavity nesters (Aitken 2002). Cavity nesters are further classified as excavators and non-excavators based upon excavation carried by birds themselves or occupying the already existing cavities. Open nesters construct their nest using different dry materials like sticks, rags, twigs etc. Open nesters are more prone to natural predation than the cavity nesters as cavity nesting provides relatively more shelter from the predators as well as conserving energy (Martin and Li 1992).

Nest site selection act as a major factor in habitat selection by birds and is greatly influenced by food availability, presence of suitable nest material, protection from predators and suitability of area (Collias and Collias 1984). Likewise, the old and tall trees are preferred by birds like hawks and eagles and the cavity nesters like parakeets (Sandhu 1993). Larger birds generally prefer their nest construction on the top of the trees while smaller birds usually try to occupy the lower part of trees canopy (Ali and Ripley 1983). Woodpeckers, Parakeets and Barbets excavate their nests in tree trunks or branches while Hornbills, Common Myna,

Brahminy Myna prefer to use the existing natural tree cavities for nesting

Gajera *et al* (2009) observed 103 terrestrial bird species in Danta forest in Gujarat during his investigation. Of these, nesting of 31 species was recorded. The highest number of nests were made by Baya Weaver (16), followed by House Crow (14) and Green Bee Eater (12). Thirty seven nests were of hole-nesting birds, while the remaining birds were non-hole nesters. Rose Ringed Parakeet was observed nesting in both natural tree holes and cervices on wall of buildings.

Nan *et al* (2006) surveyed nesting sites of White Eared Pheasant in southwestern Sichuan Province, China and found 13 nests in total. Oak shrub was greatly preferred as nest sites (84.2%) followed by nests under a rock wall (7.69%) and a fallen tree (7.69%). In Zhujie area, one nest was in forest and 11 nests were found in Oak shrubs.

Birds mostly prefer to use plant material for nest building that is readily available in bird's own territory which varies from plant fibers to grasses, twigs of varied sizes or weeds. For instance, larger twigs are preferred by larger birds for constructing stable platforms, while smaller birds prefer to use finer materials like small grasses, fibers for constructing compact, cup type nests (Collias and Collias 1984). According to Kaur (2005) small tree twigs, leaves, roots and grasses, feathers, pieces of clothes and polythene are used as nesting material by Common Myna. Such supplement materials were used either for forming a bed cushion for safe egg laying or for strengthening the nest.

Most of the workers claim that birds mainly depended upon trees for their nesting. Even aquatic birds like Egrets, Herons and Water-hens, which otherwise inhabited water bodies for their food requirements, prefer their nesting on trees (Sandhu 1993). Building of nests on large and tall trees helps birds not only to reduce predation, but also provide protection from stormy winds and rains. Some birds built nests close to the ground amidst thick bushes to elude avian predators (Andheria 2002). Birds may exhibit flexibility in their nest-site selection as in case of non availability of suitable site for nest building; birds make use of the alternate places or locations (Pandey 1991).

During his investigation Sandhu, (1993) found that Pied Myna has made use of 24 tree species while Common Myna, House Crow, Ring Dove, Rose Ringed Parakeets and Black Drongo built nests on 16, 15, 12, 8 and 7 tree species respectively. Birds avoid using old or already existing nests since these are usually familiar to predators and competitors (Sedwick and Knope 1992). The nesting failure or mortality was generally found to occur due to the habitat destruction and predation in many cases (Jimenez and Conover 2001). Studies on population status and habitat-use pattern of Indian White-backed Vulture (*Gyps bengalensis*) in Himachal Pradesh revealed the presence of 22 nesting colonies of this species, supporting 77 nests, of which, only 56 pairs bred successfully during breeding season (October to March/April) in 2010 to 2011 (Thakur and Narang 2012).

Nest-site selection is considered to be an important component of habitat selection by birds. Some birds like Ring Dove, Common Myna and House Crow prefer dense canopy which provide protection to their nests and contents by concealment. Others like pigeons prefer exposed perches for nesting. Different bird species have different requirements for nesting. Mesquite trees are the preferred nest sites for Albert's Towhees and Long-eared Owls (Bulls *et al* 1989) whereas short grass habitat is preferred by Loggerheaded Shrikes (Gawlik and Bildstein 1990). Baya Weaver birds prefer thorny trees near or away from water bodies. Streaked Weaver bird nests on *Typha* species growing with in or around water bodies, whereas Blackthroated Weaver bird nests in *Saccharum spontaneum* bushes (Dhindsa 1980). Bald Eagles generally nests on prominent features that overlook aquatic habitat (Anthony and Isaacs 1989). Cavity nesting birds require snags (Land *et al* 1989). Studies indicate that food availability is considered one of the most important factors limiting bird populations (Strong and Sherry 2000).

However bird species which are ground foragers or ground nesters including Ovenbirds, Verry and Ruffed Gouse may have greater predation risk because of increased visual obstruction (Fernandez-Juricic *et al* 2002).

Humans affected bird nesting success in several ways, ranging from habitat destruction to the introduction of new predator species. Habitat fragmentation causes direct loss of nesting habitat features needed by breeding birds. Habitat loss led to a decrease in potential nest sites affecting nesting success as birds were forced to use unsuitable nest sites. In the absence or scarcity of suitable nesting sites some birds made their nests at odd places like electric transmission cables (Toland 1990), on telephone and electric poles (Mudappa 2000), top of building roofs (Ali and Ripley 1983), underneath river bridges, inter spaces among girders, window lodge and chimney (Truslow 1979), sewage, gas pipes and radio transmitter masts (Sangha and Naoroji 2004). Information about the nesting habitats of birds, including those needed for successful nesting, provided a better understanding of the ecological factors that permitted coexistence of different species and helped in conservation efforts (Purcell and Verner 2008).

2.1.3 Roosting

A roost is defined as a place where birds rest during a long inactive period. All birds roosted with a period of inactivity analogous to sleep in human beings. Roosting behavior and roost selection were important determinants of individual fitness (Fisher *et al* 2004). Few birds prefer to roost alone, while others prefer to roost in flocks and they select various kinds of habitation for this activity. Roost selection was vital component of the overall habitat selection process. Large bird species generally prefer tall trees whereas small ones prefer small trees of lower canopy (Ali and Ripley 1983). Even dead and hollow tree trunks are very important for roosting of birds (Bull and Copper 1991).

Many ground birds, such as quails and pheasants prefer their roosting in trees. Buckley and Buckley (1968) found a few parrots of the genus *Loriculus* roosting hanging upside down, while some birds sleep during flight (Rattenborg 2006).

The most important features for roost tree selection were the physical characteristic i.e. structure of a tree (Trivedi 1993). Birds particularly selected dense vegetation related to frequency as well as, covered with good canopy and tree height (Rumble 1992).

According to Trivedi (1993) in Gir forest no roost tree was located close to the road to avoid the disturbance caused by vehicles. Dodia (2011) stated that water was a most important factor for selecting roost site. Trivedi and Johansingh (1996) also stated that the distance from water carried secondary importance in Gir forest and other notable factor for roost selection was road site. Foraging, roosting, and nesting habitats of the avian fauna of the Agmon wetland, northern Israel were studied by Ashkenazi and Dimentman (1998). Prajapati and Prajapati (2012) also studied on roosting habitat of Rose Ringed Parakeet. Roosts and roosting habits of Rose Ringed Parakeet was studied near canal side cultivation in Central Punjab, Pakistan (Khan and Beg 1998). Dodia's (2011) worked related to roost tree selection of Indian Peafowl. Studies were conducted on roosting and nesting habits of free ranging Indian Peafowl (*Pavo cristus*) in Southern Tamilnadu by Subramanian and John (2001). According to Prasharya and Mukherjee (1999) roosting of Peafowl on electric pole indicated adaptability of the species to a modified habitat. According to Santhanakrishnan *et al* (2010) birds show different preferences for roosting like trees, manmade structures, nest boxes and even wells. They also concluded that the Spotted Owlet (*Athene brama*) preferred structurally complex roost trees with well branched, high canopy densities with thick green foliage, large diameter with various height classes of trees for roosting.

Ward *et al* (1998) suggested that birds selected roost sites based on the distribution of their prey. Many investigators have reported that the canopy density was related to roost site selection by various owl species viz. Spotted Owl *Strix occidentalis* (Barrows 1981), Mexican Spotted Owl *Strix occidentalis lucida* (Young *et al* 1998) and Eastern Screech Owl *Otus asio* (Trango *et al* 2001).

2.2 Birds are dependent on vegetation cover to protect themselves from predation and even during migration.

2.2.1 Predation

In addition, in temperate forest many studies have shown an increase of predation on bird nests at forest edges (Schmiegelow & Monkkonen 2009). Nevertheless, this effect would be more dependent on the type of landscape found in the surrounding of the edge area. There would be an increased predation when the edge is beside an agricultural land, but in other cases (for example if the edge cut is still inside a forest land) this aftermath is not evident (Monkkosen *et al* 2000). This highlights the difference of effects between an edge created by

forest harvesting and an edge as a result of forest clearing for agriculture. Corvids, which can be predators for certain bird species, are more numerous in agricultural lands (Andren 1992). This is one of the elements that could explain why predation would be strengthened at edges close to agricultural areas. Hahn and Hatfiels (1995) also underline that parasitism is higher in a large portion of the forest, if this one is situated close to agricultural infrastructures such as fields, cattle farms.

2.2.2 Migration

Among the many challenges birds face, such as predators, (Lind and Cresswell 2006), exhaustion (Yong *et al* 1998), inhospitable weather (Richardson, 1978), and inter- and intra-specific competition (Moore and Yong 1991), birds must make critical decisions regarding resource selection at stopover habitats during migration (Smith *et al* 2007, Rodewald and Brittingham 2007). Using optimal stopover habitat allows birds to refuel efficiently and thus to depart as quickly as possible to the next stopover location or breeding area (Schaub *et al* 2008).

Birds that arrive in breeding habitat earliest maximize opportunities to produce offspring that survive (Norris *et al* 2004).

2.3 Other studies

Ireland supports some internationally significant populations of birds and possesses some notable woodland subspecies such as jay (*Garrulus glandarius hibernicus*) and coal tit (*Periparus ater hibernicus*) (Nairn and O'Halloran 2012). Of 199 bird species assessed in Ireland, 25 were on the Red list, 85 on the Amber list and the remaining 89 on the Green list (Lynas *et al* 2007). Red is the highest conservation priority, with species needing urgent action, amber include species of moderate conservation concern, whereas green-listed birds are not threatened.

Trees offer a habitat to birds and density of birds is directly related to the presence of suitable habitat. Presence of maximum tree species in Woodland Wildlife park i.e Jinnah Garden supported large number of avian species. Study also shows that density of birds in new sites is less as compared to older sites because of disturbed habitat, higher exotic species and human disturbance. So there is a need to plant more native trees in new sites than exotic species for survival of many native bird species (Tanveer *et al* 2002). Several texts (Smith-Dodsworth 1991) recommend native trees and shrubs that are thought to attract birds into city gardens.

Botanical garden of Punjab University, Lahore, Pakistan is spread over 50 acres. Tree composition of botanical garden is dominated by *Acacia arabica, Pinus longifolia roxburghii, Acacia nilotica, Dalbergia sissoo, Melia azadarach* and *Heterophrgama adenophyllum.* Moreover, fruits of Peepal, Mulberry, Neem and Shisham have attraction for frugivorous species like Parakeets and Bulbuls. Lawns of University are best habitats for many birds like

Babblers, Blue Rock Pigeons, Mynas, on common trees like Shatoot (*Morus alba*), Shisham (*Dalbergia sissoo*), Drek (*Melia azadarach*), Pipal (*Ficus religiosa*) and many ornamental plants. Many birds like Crow, Weavers etc. are seen roosting and nesting on these trees (Tanveer *et al* 2002). Eucalyptus plantations are considered as poorest habitat with regard to avian communities (Pina 1989, Telleria and Galarzra 1990).

The factors influencing the most the bird repartition are different according to the species. Within one bird community forest-interior specialists, interior-edge specialists, interior-edge generalists, edge and field edge species can be distinguished (Brazaitis 2005). Thus certain species seem to be much sensitive to the changes in forest composition and structure that have occurred. Interior species are more sensitive since birds of this group cannot shift and live at the edges of the forest.

Impacts are also different between resident and migrant species. Resident species are influenced by the decrease in size of suitable habitat since, staying in the same area during the whole year, they need a larger area to forage (Lindenmayer *et al* 2002). In Fennoscandia, workers found that the populations of resident bird species that depends on old successional forest stages has declined whereas the populations of migrant species, that prefers clearcuts or young forests has shown a corresponding increase. The most important causes for the decline of resident species would be the loss of old boreal stands on one hand, and on the other hand the decrease of the total amount of deciduous trees, mainly aspens and birches (Angelstam and Mikunski 1993).

From the human modified habitats, agroforestry systems such as shade coffee (*Coffea arabica*) and cacao plantations (*Theobroma cacao*) have been shown to support greater number of forest bird species with higher diversity than the open agricultural systems with few or no trees (Petit *et al* 1999).

Plantation forests provide potential habitat for birds that utilize woodland habitat, and native woodlands offer a reference point against which to compare the bird assemblages of non-native plantations. While direct comparisons between plantations and more natural woodlands are not always appropriate (Brockerhoff *et al* 2008), such comparisons are useful in identifying facets of the woodlands that differ between the woodland types. Because management affects the utility of plantations to birds (Lantschner *et al* 2008) such comparative studies may therefore provide useful information on aspects of plantations that can be improved with a view to sustainable forest management and biodiversity conservation. Bird assemblages can differ between native woodlands and non-native plantations (Sax 2002) and non- native plantations may host fewer species at lower densities than native woodlands (Farwig *et al* 2008). However, in certain situations, non-native plantations may also possess similar bird species richness to native woodlands (Sax 2002, Magura *et al* 2008). Because specialist woodland bird species are more likely to be absent from plantations than

generalists. Ireland offers an excellent opportunity to test whether patterns of bird assemblages in plantations are more similar to native woodlands in regions lacking a specialist woodland bird fauna than in regions that have a specialist woodland bird fauna.

In Britain, Oak supports more invertebrate species than Ash (Kennedy and Southwood 1984) and, as a result, food availability for breeding birds may differ between these woodland types, which may in turn influence bird assemblages. The occurrence of Robin as an indicator for both native woodlands and Mid-rotation plantations reflects the ability of this species to utilize a wide range of habitats (Fennessy and Kelly 2006).

Reduction in the area of suitable habitat resulted in decrease in bird population due to decline in adequate space for territories, nest sites, etc. (Rolstad 1991). Because of their quick response to habitat changes and high mobility, birds were found to be suitable for studying ecological effects of interventions in natural systems through urbanization, industrialization, etc. (Savard *et al* 2000). Bird communities are also greatly affected due to habitat fragmentation as they response to different environmental gradients through changes in species composition, decreased overall regional diversity, increased population densities and changes in community structure (Chace and Walsh 2006, Huste and Boulinier 2011). The bird community of fragmented habitats was influenced by the type of vegetation, which favoured species that utilized small and discontinuous patches of vegetation, and the bird populations were strongly correlated with the size of native and exotic vegetation (Mills *et al* 1989).

The community structure of bird species shows a great variation in different habitats like agriculture farmlands, on trees, grasslands and other areas (Chakravarty and Sandhu 2002). Winkler (2005) found that the vegetation structure, its complexity and spatial dispersion are the important factors in determining bird community composition. Hilly and mountainous landscapes owing to the heterogeneity of structure and physiognomy in vegetation cover and the availability of sufficient supply of seasonal resources attracts relatively more bird species (Farina 1989). Few workers investigated that cultivation of crops and management practices affects the composition and structure of bird assemblages (Malhi 2006). The attributes of roadside vegetation, an important bird habitat in grassland ecosystems, have been shown to affect bird abundance, distribution composition, and diversity (Shochat *et al* 2004).

In a comparative study on the structure of bird communities in three types of forests in Nainital district, Uttarakhand, Joshi and Bhatt (2013) observed that the pine mix forest had high number of unique species than the sal and oak forests.

Yoganand and Davidar (2000) studied the habitat preferences of 30 species of forest birds in Baratang Island, Andaman and analysed the habitat preferences. The seasonal variations of the non-migratory birds were reported by Neelakantan (1976). Dhindsa *et al* (1988) studied bird community of an intensively cultivated area at Ludhiana in March-April

and recorded a richness of 68 species.

Many workers have described the structure of bird communities, their habitat associations and preferences for roosting and nesting. They discussed how Bald Eagles, *Haliaetus leucocephalus* prefer perching on Ponderosa pine (*Pinus ponderosa*), Snags and Cottonwoods *(Populous* spp.) (Fielder and Starkey 1986). When large number of bird species forage on the same tree species, they generally occupy different niches to avoid competition. Foraging niches of foliage-gleaning birds in Finland have been described by Virkkala (1989).

2.4 Other factors determining bird composition

2.4.1 Urbanisation

There is always a positive correlation between the volume and structure of native vegetation and native bird diversity (Chace and Walsh 2006). Studies of bird communities in urban parks have shown that parks are considerably richer in bird species diversity and richness than other urban habitats (Jokimaki 1999). Red Vented Bulbul, Indian Robin and Purple sunbird were the birds observed in urban parks. Urbanization often modifies landscapes and land use patterns, leading to changes in the vegetation and altering species composition (Kler and Kumar 2015). Urbanization affects species composition and abundance, moulding few species to dominate the urban environment (Arora *et al* 2016). Urban habitats are often of superior quality to raptors because there are often free from persecution and have an adequate food supply allowing use of otherwise unsuitable or unprotective nesting sites. Avian fecundity in urban areas is a reflection of species-specific adaptability to urban resources and to levels of nest predation and nest parasitism (Chace and Walsh 2006).

Continuously increasing urbanization has resulted in diminishing bird communities (Melles *et al* 2003). The number of species has declined due to increasing urbanization and that the remaining group of species was dominated by highly abundant species. Melles (2005) found that the distribution and composition of bird species were also adversely affected by urbanization and industrialization. With rapidly reducing forest cover, the species composition has changed and the community was dominated by more urban-adapted species (Melles *et al* 2003).

Kachare *et al* (2011) investigated that man-made disturbances were responsible for the decline in species diversity index and species count of migratory birds in wetlands of Kolhapur City in Maharashtra.

Naithani and Bhatt (2012) provided a base line data about bird community structure in urbanized and natural habitats along altitudinal gradient in Garhwal Himalaya (Uttarakhand). Sengupta *et al* (2014) have observed more number of rare species and higher percentage of unique species at rural sites in their studies on bird community structure along urbanization gradient around Kolkata.

Khan (2003) investigated the avifauna of a wetland, heavily encroached with water hyacinth, in a densely populated industrial area near Kolkata in West Bengal. Study revealed that the bird community has changed and became poorer over a period of twelve years. High diversity of (239 species) birds was recorded from Chandigarh at the foothills of the Shivalik hill range (Thakur and Paliwal 2012).

Diverse vegetation and open green spaces of Sprawling University campuses have been important components of the urban landscape, providing sanctuary for rich avian diversity and communities (Gupta *et al* 2009). Pidgeon *et al* (2007) conducted a study in the United States and found that housing density and human populations have substantially increased in and near forests, both on fringes of cities and in rural areas, which effect the development and biodiversity of birds.

Changes in land use pattern are responsible for threatening the biodiversity of region. Bird communities of Himalayan forests, in particular, are of conservation concern (Renner 2011), because many endemic species within the region are largely dependent on primary forest ecosystems. Land use change within Himalayan mountain habitats has disproportionately negative effects on bird communities, because the adaptive response of species associated with these habitats is restricted (Norbu *et al* 2013). Thus, Himalayan forest bird communities likely face challenges in adapting to primary forest disturbance and loss, which is occurring at a rapid rate in the region (Brandt *et al* 2012).

Rapid population growth, cultural change, and economic development are the primary threats to these forests; all of these have led to accelerated rates of land use change and destruction of natural habitats (Brandt *et al* 2012).

Tropical mountains are acknowledged for harbouring high diversity of avifauna with many coexisting species within habitat types (Jankowski *et al* 2009). Forests are the most significant habitat for birds which supports around 75% of all bird species while only 45% of all bird species have adapted to humans modified habitats (BirdLife international 2008). Human activities such as farming, settlement, charcoal making, pole cutting and firewood collection have contributed in the degradation of forests which has extensively damaged the natural habitat of birds, affecting their variety and variability (Storch *et al* 2003).

Birds are habitat specific and some can occupy more than one habitat type, however because of changes in land uses, most of the birds have been displaced from their original habitats (Burgess *et al* 2002).

Birds select habitats that fit their requirements for successful reproduction and survival though some generalist species may utilize several habitats (Rodríguez-Estrella 2007). Differences in requirement among bird species have caused specificity on habitat requirement (Buckley and Freckleton 2010). For example Mountain plover (*Charadrius mountainus*) feeds primarily on insects (grasshoppers, crickets, beetles, flies, ants); uses

ground for nesting and prefer short grass while Mongolian sand plover (*Charadrius atrifrons*) feeds on invertebrates (molluscs, worms, crustaceans especially crabs and insects), uses tree for nesting and prefer shore of the lakes. Therefore habitats, either terrestrial or aquatic restrict bird species distribution and diversity. In most habitats, plant communities determine the physical structure of the environment, and therefore, have a considerable influence on the distributions, abundance and diversity of birds and interactions of other animal species. For example, for bird species diversity in forests, Tewes *et al* (2004) evidenced that the physical structure of a plant community, i.e. how the foliage is distributed vertically, may be more important than the actual composition of plant species. Ranganathan *et al* (2007) found that farmland also has been an important habitat for farmland bird showing that some bird species are habitat specific though some are generalist. Currently, due to land uses changes it is difficult to find forest habitat covering large areas. For example near towns, most of the land has been converted to settlement and farmlands. The study of bird species diversity, distribution and abundance become important not only for knowledge but also for conservation purposes as birds has been used as ecological indicators (Rittiboon and Karntanut 2011).

2.4.2 Habitat features

Habitat features such as floristic complexity, cover and density of vegetation are the important factor in bird habitat selection. When these features are correlated they show positive correlation, since they provide food, nesting material and cover for predator (Whittingham and Evans 2004). Heterogeneity of the habitat features can play a big role in the determination of species abundance and occurrence within a habitat type (Pennington and Blair 2011). Removal or reduction of vegetation reduces the total area of contiguous habitat available to birds and increases the isolation of the habitat which results in fragmentation. The fragmented habitat provide way to various predators that can successfully exploit by eating bird eggs, young and even adults which impact bird populations (Schlossberg and King 2008).

2.4.3 Anthropogenic factors

Habitat destruction, fragmentation and loss have been observed due to increase of human population (Manhães and Ribeiro 2005). Forests have been converted to urban settlement, agricultural field and pasture land, sometimes to open land. These human activities have an impact on bird species abundance, distribution and diversity due to isolation and fragmentation (Westphal *et al* 2006). Various environmental factors (climatic condition, topography and habitats) and human interventions determine bird species diversity and abundance (Rodríguez-Estrella 2007, Jankowiski 2009).

Decline in abundance and loss of species due to human interference have been observed in the tropics (Cordeiro, 2005). This concurs with the studies of Doggart *et al* (2005)

on Uluguru Mountains. The results indicate that diversity and distribution of birds are affected by human activities in the Uluguru forest reserve. It has been found that areas with human activities are a threat to biodiversity contrary to Andren (1994) who found that the disturbance can become an important term of species richness or abundance if only the percentage of habitat decreasing below 20–30% is the continuous chain of thin habitat. This had been witnessed by Marzluff (2005) when the study found that local scale bird diversity is enhanced by moderate settlement. The research done in Morogoro region by Doggart *et al* (2005) had given attention to the protected area (Uluguru Nature Reserve) without considering other habitat types outside the protected area system such as farmlands, settlement area and open shrubland which occur at the foot of the mountain. Basing on the idea that birds are widely distributed, these habitats may become important for avifauna survival.

Birds are very visible and integral part of the ecosystem occupies many trophic levels in a food chain ranging from consumers to predators. Their occurrences have been helpful as environmental health indicator, plant pollinators and seed dispersal as well as pest controller (Ramchandra 2013). Furthermore they do add enjoyment to our lives because of their distinctive colours, showy display also distinctive songs and calls.

The Study on diversity, distribution and abundance of birds with respect to different habitat types is important since will provide an understanding on the avifauna diversity, distribution and abundance within natural and human occupied habitats.

As a means of promoting the benefits of trees as habitat and food for other biodiversity, it is often stated that indigenous (native) trees should be encouraged above alien (exotic/non-native) species, because the services that they provide are already part of the local ecology, and other native species will have co-adapted with them. These works present several examples of local biodiversity plans or urban ward authorities specifically regulating for native species over alien ones. Thus, from a biodiversity conservation perspective, indigenous trees are often seen as more beneficial for other native species than are alien ones. However, there has been limited empirical evaluation of this claim in urban settings. This is particularly so for street trees.

CHAPTER III

MATERIALS AND METHODS

Present study was conducted on avian diversity in relation to indigenous trees. The study was carried out from April 2016 to March 2017. Two different locations were selected i.e Punjab Agricultural University, Ludhiana and rural area of village Machaki Mal Singh falling in district Faridkot.

Location I: Punjab Agricultural University, Ludhiana

The University Campus is situated towards the west of city at latitude of 30˚ 56' N, and longitude of 75˚ 52' E and 247 m above sea level on the side Ferozepur road. Campus consists of agrifields, buildings, poultry sheds, fish ponds, research farms, orchards, nursury, forestry area and CIPHET. Each area has distinct variety of vegetation, cropland, food availability etc. it provides good habitat for bird community.

Location II: Village Machaki Mal Singh, Faridkot

Village is situated 10 km away from district Faridkot at latitude of 30˚ 37' N and longitude of 74˚ 44' E. Village area consists of residential area comprising of modern and old traditional housing structure, Anaj mandi, ponds, canals and agrifields. Vegetation structure includes both indigenous trees and exotic trees. Different types of vegetations at different sites provide diverse habitats to avifauna.

Six different types of indigenous trees were selected while three trees of each type for the present study. At location I trees were selected from different sites i.e Agrifield of PAU, Orchard area, Agrifield of poultry farm and Fisheries pond area. At location II trees were selected from area around canal, Agrifield area and Peripheral area of village. Three trees of each type were selected

Table 1: Trees selected for study:

S.No.	Tree	Scientific name
1	Banyan	*Ficus benghalenesis*
2	Jamun	*Syzgium cumini*
3	Mulberry	*Morus alba*
4	Neem	*Azadirachta indica*
5	Pipal	*Ficus religiosa*
6	Sheesham	*Dalbergia sissoo*

3.1 Description of study areas of Location I

3.1.1 Communication centre: Area of communication centre included trees like Palm (*Pheonix dactylifera*), Pilkan (*Ficus lacor*), Pipal (*Ficus religiosa*), Banyan (*Ficus benghalensis*), Sheesham (*Dalbergia sissoo*) surrounded by buildings and fields on other side.

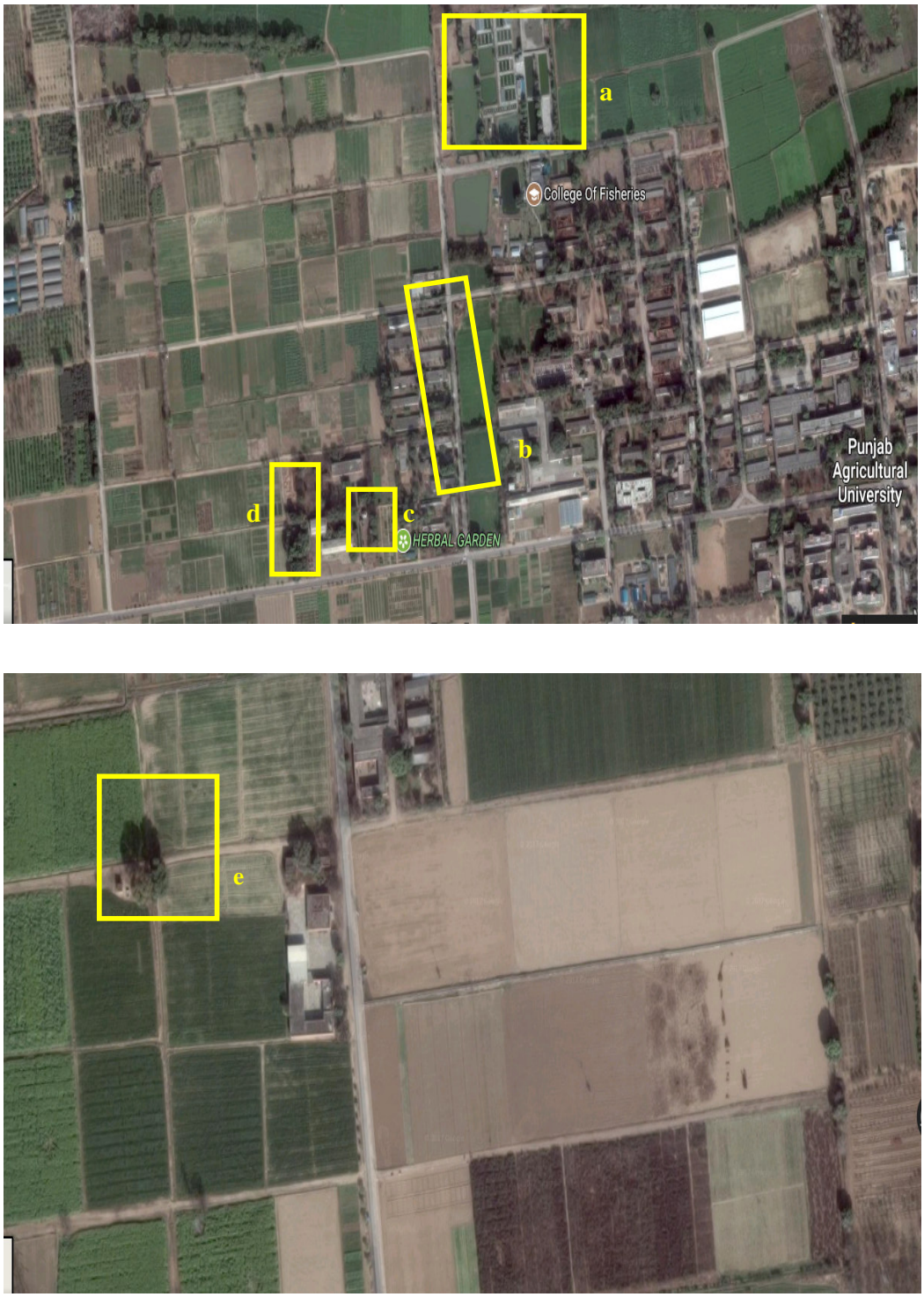

Plate 1: **Maps showing areas of location I: (a) Area of Colleges of Fisheries (b) Area of Poultry farm (c) Area of IGMRI (d) Tube well no. 1 (e)Tube well no. 5**

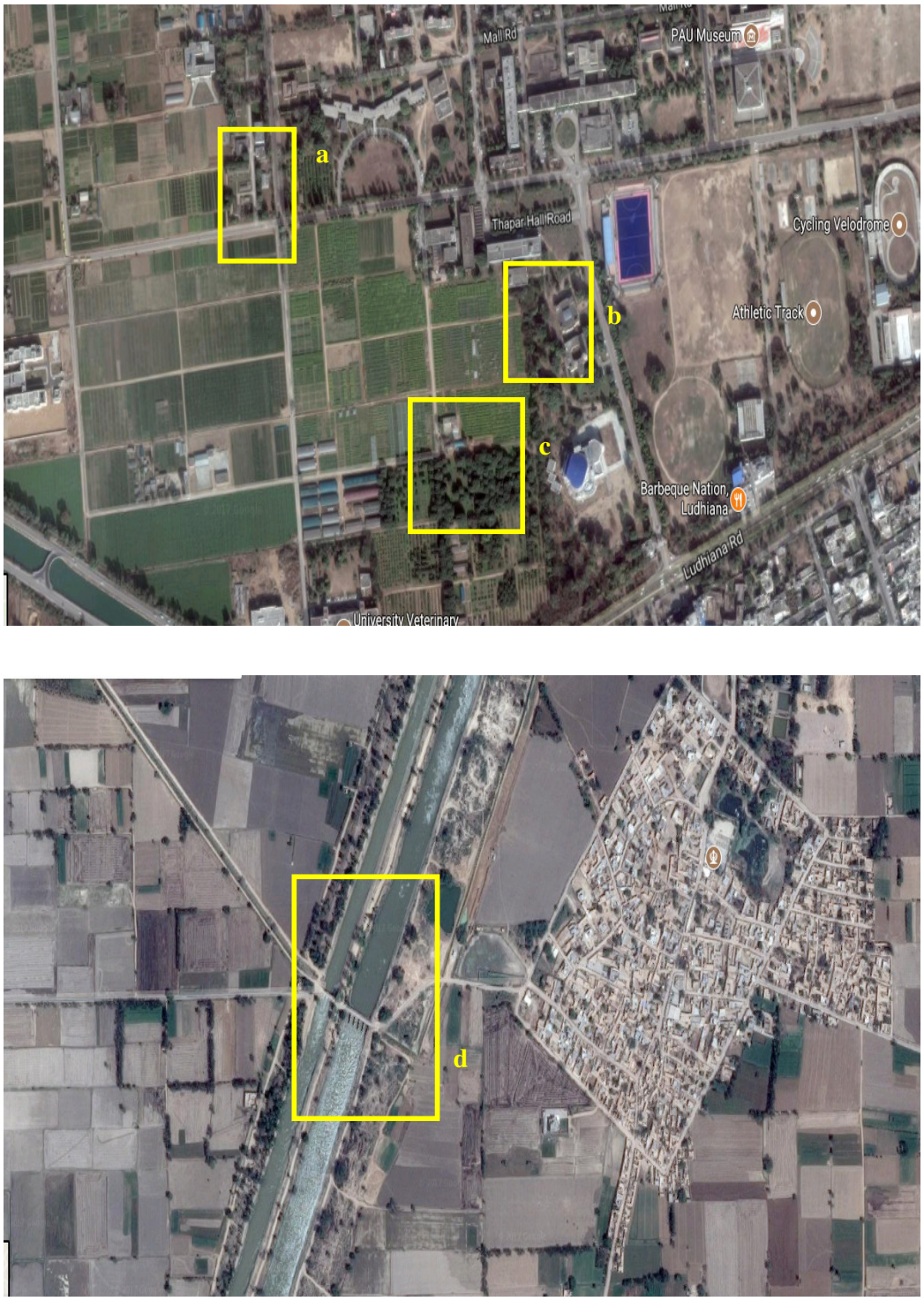

Plate 2: **Maps showing : (a) Area of Entomology Farm (b) Area of Communication Centre and international linkages (c) Orchard area (i) Canal area of location II**

Plate 3: Map showing area of location II: (a) Peripheral area (b) Farm area

(Plate 4)

3.1.2 Tube well no 1: Trees with huge crown are the part of vegetation of this area i.e Pipal (*Ficus religiosa*), Banyan (*Ficus benghalensis*). Other trees present at this site were Mango (*Magnifera indica*), Dhrek (*Melia azedarch*), Mulberry (*Morus alba),* Sheesham (*Dalbergia sissoo*) and Beri (*Ziziphus mauritiana*). Surrounding fields were covered by vegetation of pulses, Wheat (*Triticum aestivum*), Rice (*Oryza sativa*) and other vegetables grown in rotation throughout the year. (Plate 4)

Table 2: Sites selected at location I and location II

Sr.No	Trees	Location I	Location II
1	Banyan	Communication centre and international linkages	Canal area
		Tube well no 1	Farm area
		Agronomy farm	Peripheral area
2	Jamun	Orchard area	Canal area
		Area of College of Fisheries	Farm area
		Entomology farm	Peripheral area
3	Mulberry	Agronomy farm	Canal area
		Area of poultry farm	Farm area
		Tube well No. 1	Peripheral area
4	Neem	IGMRI area	Canal area
		Area of College of Fisheries	Farm area
		Entomology farm	Peripheral area
5	Pipal	Communication centre and international linkages	Canal area
		Tube well no 1	Farm area
		Agronomy farm	Peripheral area
6	Sheesham	IGMRI (Indian Grain Storage Management and Research Institute)	Canal area
		Tube well no 1	Farm area
		Tube well no 5	Peripheral area

3.1.3 Agronomy farm: Area of agronomy farm included trees i.e Pipal (*Ficus religiosa*), Silver oak (*Grevillea robusta*), Mulberry (*Morus alba*) and understory vegetation was grassy. Few buildings were also the part of this site. (Plate 4)

3.1.4 Area of poultry farm: This area comprised area around fodder section and poultry farm fields (Plate 4). Only the rotation of fodder crops was observed in this area. Tree diversity of this area comprised of Pipal (*Ficus religiosa*), Mulberry (*Morus alba*), Dhrek (*Melia azedarch*), Bottle brush, Chukrasia (*Chukrasia tabularis*) and Pilkan (*Ficus lacor*).

3.1.5 Fisheries area: This area included fish ponds along with plantation of Jamun trees on both sides of fish pond. Other trees present in this area were Mango (*Magnifera indica*), Palm (*Phoenix dactylifera*), Safeda (*Eucalyptus tereticornis*), Ficus panda species, Banyan tree (*Ficus benghalenesis*) and grassy vegetation. (Plate 4)

3.1.6 Tube well no 5: This area included crop rotation of Wheat (*Triticum aestivum*) and Rice (*Oryza sativa*). Other crops grown in this area were Arhar (*Cajanus cajan*), Maize (*Zea mays*), Bajra (*Pennisetum glaucum*) Soybean (*Glycine max*), Sarso (*Brassica juncea*). Dhrek (*Melia azedarach*), Pipal (*Ficus religiosa*), Mulberry (*Morus alba*), Kachnar (*Bauhinia purpurea*), Sheesham (*Dalbergia sissoo*) trees were the part of vegetation of this area (Plate 4).

3.1.7 IGMRI – This area included building for storage of grains. Surrounding vegetation of building consists of grass and trees like Mango (*Magnifera indica*), Ashoka (*Saraca asoca*), Sheesham (*Dalbergia sissoo*), Neem (*Azadirachta indica*), Safeda (*Eucalyptus tereticornis*). (Plate 5).

3.1.8 Entomology farm: This site consisted of buildings and trees like Silver Oak (*Grevillea robusta*), Kanak Champa (*Pterospermum acerifolium*) Neem (*Azadirachta indica*), Jamun (*Syzgium cumini*), Date Palm (*Phoenix dactylifera*) and Citrus fruits. Crop vegetation in nearby fields includes wheat and Barrasica (Plate 5).

3.1.9 Orchard area: Most of the area of orchard was covered by fruiting trees i.e. Mango (*Magnifera indica*), Jamun (*Syzgium cumini*), Kinnow (*Citrus reticuleta*), Rough Lemon (*Citrus jambhiri*), Daisy, Loquat (*Eriobotrya japonica)*, Sapota, Guava (*Psidium guajava*), Bael (*Aegle nilotica*) and various other Citrus species. Few buildings were also part of this area (Plate 5).

3.2 Description of study area of Location II

Canal area, agrifield area and peripheral area of village were three main sites selected for study. All the six selected trees were available at each of these sites. One tree of each type was selected at each site. Vegetation comprised mostly indigenous trees. Very few exotic tree species were present.

3.2.1 Canal area: Unpaved road between two canals was selected for study. It consisted of mostly indigenous tree species on both sides of roads and very few exotic tree species. This area faces very little human disturbance. Mango (*Magnifera indica*), Jamun (*Syzgium cumini*), Sheesham (*Dalbergia sissoo*), Neem (*Azadirachta indica*), Mulberry (*Morus alba*), Beri (*Ziziphus mauritiana*), Siris (*Albezia aebbeck*), Jand (*Prosopis cineraria*), Dhrek (*Melia azedarachta*), Amaltas (*Cassia fistula*) and Gulmohr (*Delonix regia*) trees were the part of nearby vegetation (Plate 5).

3.2.1 Farm area: Fields of village consisted of wheat and rice crops in rotation. Tree plantations along field sides were Kikar (*Acacia sp.),* Sheesham (*Dalbergia sissoo*), Safeda

Plate 4: **(a) Communication centre and international linkages (b) Tube well no. 1 (c) Agronomy farm (d) Area of poultry farm (e) Area of College of Fisheries (f) Tube well no. 5**

Plate 5: **(a) IGMRI area (b) Entomology farm (c) Orchard area (d) Canal area (e) Farm area (f) Peripheral area**

(*Eucalyptus tereticornis*), Popular (*Populus deltoids*), Jamun (*Syzgium cumini*), Mulberry (*Morus alba*), Pipal (*Ficus religiosa*), Banyan (*Ficus benghalenesis*), Neem (*Azadirachta indica*). Tube wells and canal irrigation water supply were the water resources available for birds (Plate 5).

3.2.3 Peripheral area of village: Outer skirts of village were considered as the peripheral area for study. This area consisted of vegetation on both sides of roads along with houses on one side and fields or plain area on the other side. Vegetation of this area included trees like Dhrek (*Melia azedarachta*), Mulberry (*Morus alba*), Neem (*Azadirachta indica*), Jamun (*Syzgium cumini*), Banyan (*Ficus benghalenesis*), Pipal (*Ficus religiosa*), Sheesham (*Dalbergia sissoo*) and Kikar (*Acacia arabica*). Crops in the fields are wheat and rice grown in rotation. Fooder crops like Barley (*Hordeum vulgare*), Maize (*Zea mays*) and (Sorghum) were also the part of vegetation (Plate 5).

3.3 Methods

Point count method was used during the study. Identification of birds was done on the basis of visual observations on their morphological characters like size, shape and color of beak, wings, feathers, eyes, legs and other parts of body by using binocular and comparing them with those described by Ali (2002) and nomenclature was done as described by Manakadan and Pittie (2002). Identification of trees was done on the basis of their morphological characters and comparing them with those described by Sahni (1998). Observations were taken twice in a week at location I and once in week at location II from 6:00-10:00 am in morning and from 5:00-7:00 pm in evening during the summer and from 8:00-11:00 am in morning and 4:0-6:00 pm in evening during winters. Care was taken that no bird was counted more than once.

3.4 Instruments used

Digital Camera (Nikon P 500), Bushnell Binocular (8X42) for observing birds and Ravi Altimeter for measuring tree and nest height were used.

Community structure: Community structure have been recorded by point count method as described above which includes species richness, relative abundance, species diversity, species evenness, species similarity and feeding guild.

3.5 Data analysis

The data of all observations of a month was pooled and the following community characteristics were calculated to quantify the bird's community at selected locations:

(a) Species richness: Total number of bird species recorded in an area.

(b) Species relative abundance: Relative abundance was calculated as: $ni/N \times 100$ where ni is the number of birds of ith species and N is the total number of birds recorded.

(c) Species diversity index: Species diversity was calculated by Shannon- Weiner Index:

$$H = -\Sigma Pi \log Pi$$

Where Pi is the proportion of the ith species of birds. 'H' is referred as 'Shannon's Index'. The whole formula is known as Shannon- Wiener index of bird's species diversity (Spellerberg and Fedor 2003).

(d) Species evenness: This was calculated by employing the formula:

$$J = H/H'max.$$

Where H represented the observed species diversity and H'max represented the log of total number of species i.e. species richness (Krebs 1985). Species evenness is also known as equitability and denoted as E which ranges between 0-1.

Statistical analysis: Annual abundance of birds was tabulated and statistical analysis using Kruskal -Wallis H test and Mann- Whitney U test were carried out using Microsoft Excel to compare the abundance of bid species on different trees and both the locations.

3.6 Nesting

The nesting studies included counting of number of nests (both active and non active), trees species used for nesting, types and height of nest from the ground level and types of materials used for building nests.

Statistical analysis: Kruskal-wallis test was carried out to find if there was significant difference for preference of nesting among tree species.

CHAPTER IV

RESULTS AND DISCUSSION

4.1 The association of bird diversity in relation to indigenous trees.

Total 52 species of birds were found on all the six tree species selected for study at both the locations (Table 3).

Table 3: Total bird species observed during study at both the locations

S. No	Common Name	Scientific Name	Feeding habits	Order
1.	Ashy Prinia	*Prinia socialis*	Insectivorous	Passeriformes
2.	Asian Koel	*Eudynamys scolopacea*	Insectivorous/ Frugivorous	Cuculiformes
3.	Asian Pied Starling	*Sturnus contra*	Insectivorous/ Frugivorous	Passeriformes
4.	Bank Myna	*Acridotheres ginginianus*	Insectivorous	Passeriformes
5.	Barn Owl	*Tyto alba*	Insectivorous	Strigiformes
6.	Bay-backed Shrike	*Lanius vittatus*	Insectivorous	Passeriformes
7.	Black Drongo	*Dicrurus macrocercus*	Insectivorous	Passeriformes
8.	Black Kite	*Milvus migrans*	Carnivorous	Ciconiiformes
9.	Black Redstart	*Phoenicurus ochrurus*	Insectivorous	Passeriformes
10.	Black-crowned Night-Heron	*Nycticorax nycticorax*	Insectivorous	Pelecaniformes
11.	Blue Rock Pigeon	*Columba livia*	Granivorous	Columbiformes
12.	Brahminy Starling	*Sturnus pagodarum*	Insectivorous/ Frugivorous	Passeriformes
13.	Brown Fish- Owl	*Ketupa zeylonensis*	Insectivorous	Strigiformes
14.	Brown-headed Barbet	*Megalaima zeylanica*	Insectivorous/ Frugivorous	Piciformes
15.	Cattle Egret	*Bubulcus ibis*	Insectivorous	Ciconiiformes
16.	Common Golden-backed Woodpecker	*Dinopium javanense*	Insectivorous	Piciformes
17.	Common Hoopoe	*Upupa epops*	Insectivorous	Upupiformes
18.	Common Myna	*Acridotheres tristis*	Omnivorous	Passeriformes
19.	Common Starling	*Strnus vulgaris*	Insectivorous/ Frugivorous	Passeriformes
20.	Common Tailorbird	*Orthotomus sutorius*	Insectivorous	Passeriformes
21.	Coppersmith Barbet	*Psilopogon haemacephalus*	Frugivorous	Piciformes
22.	Eurasian Collared-Dove	*Streptopelia decaocto*	Granivorous	Columbiformes

23.	Eurasian Golden Oriole	*Oriolus oriolus*	Insectivorous/ Frugivorous	Passeriformes
24.	Eurasian Wryneck	*Jynx torquilla*	Insectivorous	Piciformes.
25.	Glossy Ibis	*Plegadis falcinellus*	Insectivorous	Pelecaniformes
26.	Greater Coucal	*Centropus sinensis*	Insectivorous	Cuculiformes
27.	Grey Wagtail	*Motacilla cinerea*	Insectivorous/ Frugivorous	Passeriformes
28.	House Crow	*Corvus splendens*	Omnivorous	Passeriformes
29.	House Sparrow	*Passer domesticus*	Granivorous/ Insectivorous	Passeriformes
30.	Indian Cuckoo	*Cuculus micropterus*	Insectivorous	Cuculiformes
31.	Indian Grey Hornbill	*Ocyceros birostris*	Insectivorous/ Frugivorous	Bucerotiformes
32.	Indian Chat	*Cercomela fusca*	Insectivorous	Passeriformes
33.	Indian Peafowl	*Pavo cristatus*	Omnivorous	Galliformes
34.	Indian Roller	*Coracias benghalensis*	Insectivorous	Coraciiformes
35.	Indian Shikra	*Accipiter badius*	Insectivorous	Accipitriformes
36.	Indian Treepie	*Dendrocitta vagabunda*	Insectivorous	Passeriformes
37.	Jungle Babbler	*Turdoides striatus*	Insectivorous /Frugivorous	Passeriformes
38.	Large Pied Wagtail	*Motacilla maderaspatensis*	Insectivorous	Passeriformes
39.	Little Brown Dove	*Streptopelia senegalensis*	Granivorous	Columbiformes
40.	Little Cormorant	*Phalacrocorax niger*	Insectivorous	Suliformes
41.	Oriental Magpie-Robin	*Copsychus saularis*	Insectivorous	Passeriformes
42.	Pied-crested cuckoo	*Clamator jacobinus*	Insectivorous	Cuculiformes
43.	Purple Sunbird	*Nectarinia asiatica*	Plants/nectar	Passeriformes
44.	Red-vented Bulbul	*Pericrocotus cafer*	Insectivorous/ Frugivorous	Passeriformes
45.	Rose-ringed Parakeet	*Psittacula krameri*	Frugivorous	Psittaciformes
46.	Small Bee-eater	*Merops orientalis*	Insectivorous	Coraciiformes
47.	Spotted Dove	*Streptopelia chinensis*	Granivorous	Columbiformes
48.	Spotted Owlet	*Athene brama*	Insectivorous	Strigiformes
49.	White Wagtail	*Motacilla alba*	Insectivorous	Passeriformes
50.	White-breasted Kingfisher	*Halcyon smyrnensis*	Carnivorous	Coraciiformes
51.	Yellow Wagtail	*Motacilla flava*	Insectivorous	Passeriformes
52.	Yellow-legged Green-Pigeon	*Treron phoenicoptera*	Frigivorous	Columbiformes

4.1.1 Tree 1: Banyan (*Ficus benghalensis*) – It is an evergreen tree of family Moraceae. It has huge crown with the aerial roots extending to the ground which later on becomes trunk like and supports the crown. It has thick leathery leaves of oval shaped which are round at the tip. Fruiting generally occurs from March-May and also in September–October. Fruits are generally small in size and yellow to reddish brown in color.

Location I

Total 22 species of birds were found on banyan tree at Punjab Agricultural University, Ludhiana (Table 4). Species richness was maximum (16) during the fruiting period of tree, in the month of September and October. It was lowest (11) in the months June, July and January. Relative abundance of Rose-ringed Parakeet (41.74) and House Crow (36.66) was found to be maximum in the month of January and June respectively. It was lowest (0.46) of both Blue Rock Pigeon and Little Brown Dove in the month of April. Species diversity was highest in the month of September (2.18) and May (2.17). It was lowest (1.57) in the month of December. Species Evenness was found to be highest in the month of December (0.87) and it was lowest (0.71) in the month of January. Annual abundance of House Crow (27.09) and Common Myna (18.89) were found to be maximum. Indian Cuckoo and Spotted Dove were the least abundant species recorded on this tree both showing annual abundance of 0.05. Nest of Black Kite was found in the month of April and of House Crow was found in June (Plate 6, 7).

Location II

Total 15 species of birds were found on Banyan tree at village Machaki Mal Singh, Faridkot (Table 5). Fruiting on tree takes place twice in a year, first from March to May and then from September to October. Species richness was maximum (12) in the month of October, February and March followed by 10 in the month of September. This indicated that during fruiting period trees attract more birds. Species richness was lowest (6) in the month of December. Relative abundance of Common Myna (56.81) and Rose-ringed Parakeet (46.66) was found to be maximum in the month December and June respectively. It was lowest (0.97) of Indian Treepie in the month of February. Species diversity was highest in March with value of 2.03 and lowest (1.20) in month of July. Species evenness was highest (0.83) in May. It was lowest (0.62) in month of July. Annual relative abundance of Common Myna (31.17) and Rose-ringed Parakeet (24.29) were found to be maximum. Juicy figs of tree are a part of diet of many bird species (Manna 2010). Asian Koel (0.52) and Blue Rock Pigeon (0.65) were the least abundant species recorded on this tree (Plate 6, 7).

Feeding habits

At location I, abundance of carnivorous birds was 11.33, granivorous 7.46, frugivorous 16.40, insectivorous 6.08 and of omnivorous birds was 58.21 (Fig 3). At location II abundance of carnivorous birds was 1.43, granivorius 15.58, frugivorous 30.18,

Table 4: Relative abundance of bird species on Banyan tree at location I from April 2016- March 2017

	Months → / Birds ↓	April	May	June	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	March	Annual abundance
1.	Asian Koel	-	0.48	-	-	-	0.65	-	-	-	-	1.98	0.45	0.32
2.	Asian Pied Starling	1.85	2.91	-	-	-	-	-	-	-	-	-	-	0.59
3.	Bank Myna	-	-	-	-	-	1.30	-	-	-	-	-	1.83	0.32
4.	Black Kite	11.11	12.13	15.83	10.25	15.27	9.15	15.10	10.79	12.16	4.85	6.62	8.71	11.33
5.	Black Drongo	1.85	1.45	1.66	3.84	0.69	5.22	2.60	5.75	8.10	0.97	-	-	2.73
6.	Blue Rock Pigeon	0.46	0.97	-	-	0.69	-	2.08	5.03	-	-	-	4.58	1.67
7.	Cattle Egret	-	-	-	-	-	-	-	-	-	-	1.32	-	0.11
8.	Common Myna	23.14	19.90	25.00	26.92	22.22	15.03	13.02	15.82	9.45	9.70	11.25	22.47	18.89
9.	Eurasian Collared-Dove	5.09	3.88	5.83	5.76	6.94	5.22	5.20	7.19	5.40	4.85	5.96	5.50	5.61
10.	House Crow	22.68	25.42	36.66	30.12	29.16	29.41	25.00	33.09	33.78	25.42	19.86	22.47	27.09
11.	Indian Cuckoo	-	-	-	-	-	-	0.52	-	-	-	-	-	0.05
12.	Indian Grey Hornbill	-	-	0.83	-	0.69	1.96	1.56	0.71	-	4.85	4.63	-	1.13
13.	Indian Peafowl	-	0.97	-	2.56	-	0.65	1.56	-	-	1.94	0.66	-	0.70
14.	Indian Treepie	0.92	-	-	0.64	0.69	1.96	1.56	0.71	-	-	1.32	1.83	0.92
15.	Jungle Babbler	7.87	13.10	7.50	12.17	10.41	13.72	5.72	2.15	-	-	2.64	4.12	7.29
16.	Little Brown Dove	0.46	1.45	0.83	0.64	1.38	1.30	1.56	2.15	-	0.97	0.66	1.37	1.13
17.	Little Cormorant	1.85	-	-	-	-	-	-	-	-	-	-	-	0.22
18.	Red-vented Bulbul	2.77	2.42	0.83	1.28	2.08	3.26	2.08	0.71	-	-	2.64	3.66	2.10
19.	Rose-ringed Parakeet	14.81	6.79	4.16	5.76	9.72	9.80	7.81	12.23	31.08	41.74	34.43	20.18	15.27
20.	Spotted Dove	-	-	-	-	-	0.65	-	-	-	-	-	-	0.05
21.	Spotted Owlet	1.85	6.79	0.83	-	-	0.65	0.52	2.87	-	0.97	1.98	1.37	1.73
22.	Yellow-legged Green-Pigeon	3.24	1.45	-	-	-	-	1.56	0.71	-	3.88	3.97	1.37	1.13
	Richness	15	15	11	11	12	16	16	14	6	11	15	14	
	Diversity	2.15	2.17	1.78	1.87	1.90	2.18	2.05	2.06	1.57	1.71	2.08	2.10	
	Evenness	0.79	0.80	0.72	0.78	0.76	0.78	0.73	0.78	0.87	0.71	0.76	0.79	

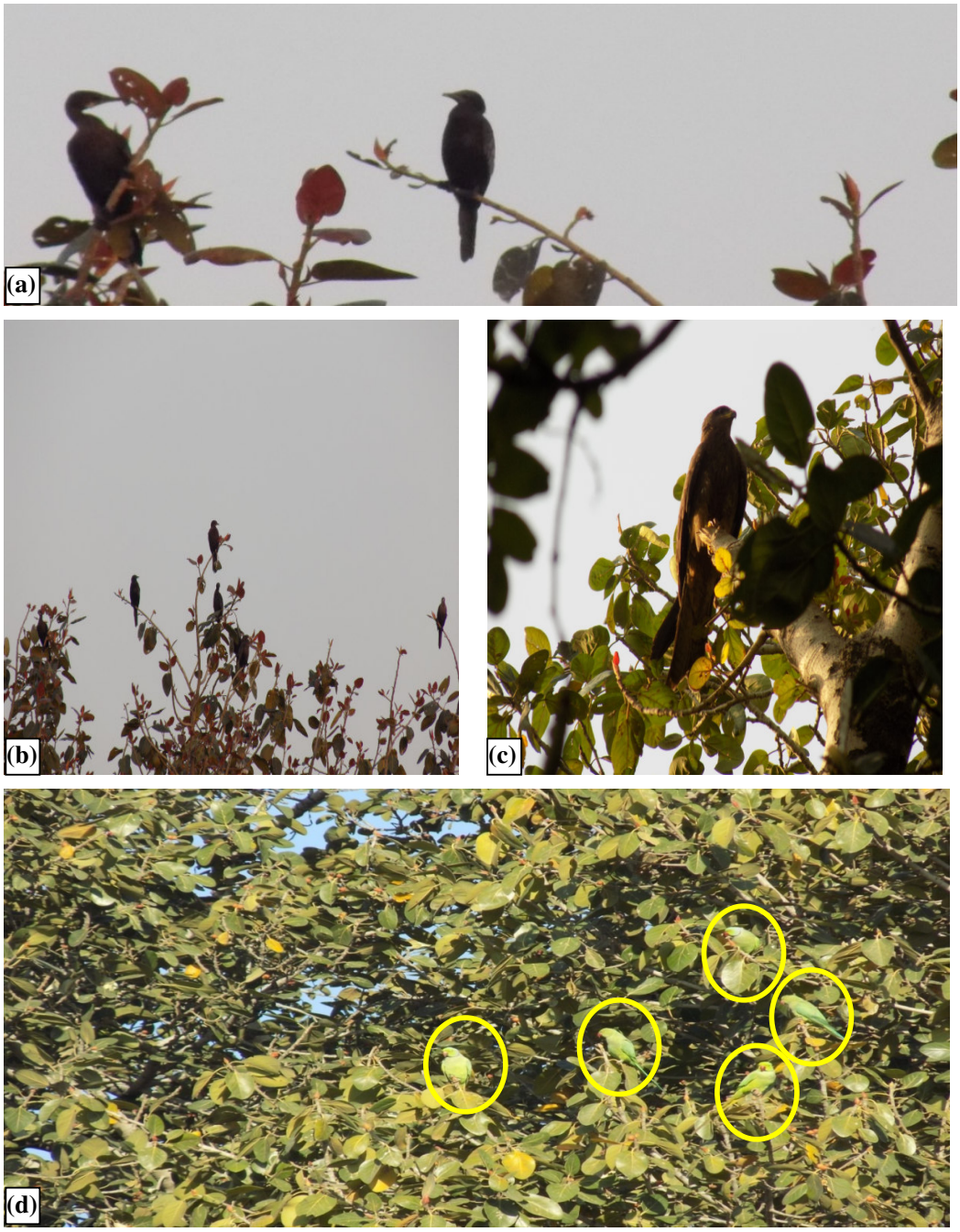

Plate 6: **(a,b) Little Cormorant on Banyan tree (c) Black Kite on Banyan tree (d) Flock of Rose-ringed Parakeet on Banyan tree**

Table 5: Relative abundance of bird species on Banyan tree at location II from April 2016- March 2017

Sr.No	Months → Birds ↓	April	May	June	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	March	Annual abundance
1.	Asian Koel	-	-	-	-	-	-	2.94	-	-	-	-	1.98	0.52
2.	Black Drongo	2.59	-	2.27	-	-	-	2.94	-	10.00	1.42	3.88		2.21
3.	Blue Rock Pigeon	-	5.55	-	-	-	1.33	-	4.25	-	-	-	1.98	0.65
4.	Cattle Egret	-	-	-	-	-	-	-	-	-	8.57	11.65	5.94	3.12
5.	Common Myna	37.66	40.47	56.81	25.00	36.53	37.33	33.82	34.04	16.66	8.57	12.62	27.72	31.17
6.	Eurasian Collared-Dove	10.38	6.94	11.36	9.21	15.38	14.66	13.23	4.89	20.00	5.71	12.62	9.90	12.07
7.	Glossy Ibis	-	-	-	-	-	-	4.41	-	-	-	-	-	0.39
8.	Indian Grey Hornbill	-	-	-	-	-	1.33	2.94	2.12	3.33	2.85	3.88	-	1.69
9.	Indian Treepie	1.29	2.77	-	1.31	5.76	1.33	2.94	2.12	3.33	1.42	0.97	1.98	1.95
10.	Jungle babbler	12.98	18.05	11.36	11.84	13.46	21.33	7.35	4.25	-	-	1.94	4.95	9.61
11.	Little Brown Dove	5.19	4.16		1.31	1.92	2.66	1.47	8.51	-	-	2.91	1.98	2.86
12.	Little Cormorant	-	-	-	-	-	-	-	-	-	-	2.91	7.92	1.43
13.	Red-vented Bulbul	3.89	6.94	4.54	1.31	1.92	4.00	1.47	4.25	-	-	0.97	2.97	2.86
14.	Rose-ringed Parakeet	22.07	9.72	13.63	9.21	25	14.66	23.52	25.53	46.66	45.71	33.98	26.73	24.29
15.	Yellow-legged Green-Pigeon	3.89	5.55	-	-	-	1.33	2.94	-	-	25.71	11.62	5.94	5.97
	Richness	9	9	6	7	7	10	12	9	6	8	12	12	
	Diversity	1.75	1.82	1.31	1.20	1.58	1.71	1.94	1.77	1.43	1.51	2.01	2.03	
	Evenness	0.80	0.83	0.73	0.62	0.81	0.74	0.78	0.80	0.79	0.72	0.81	0.81	

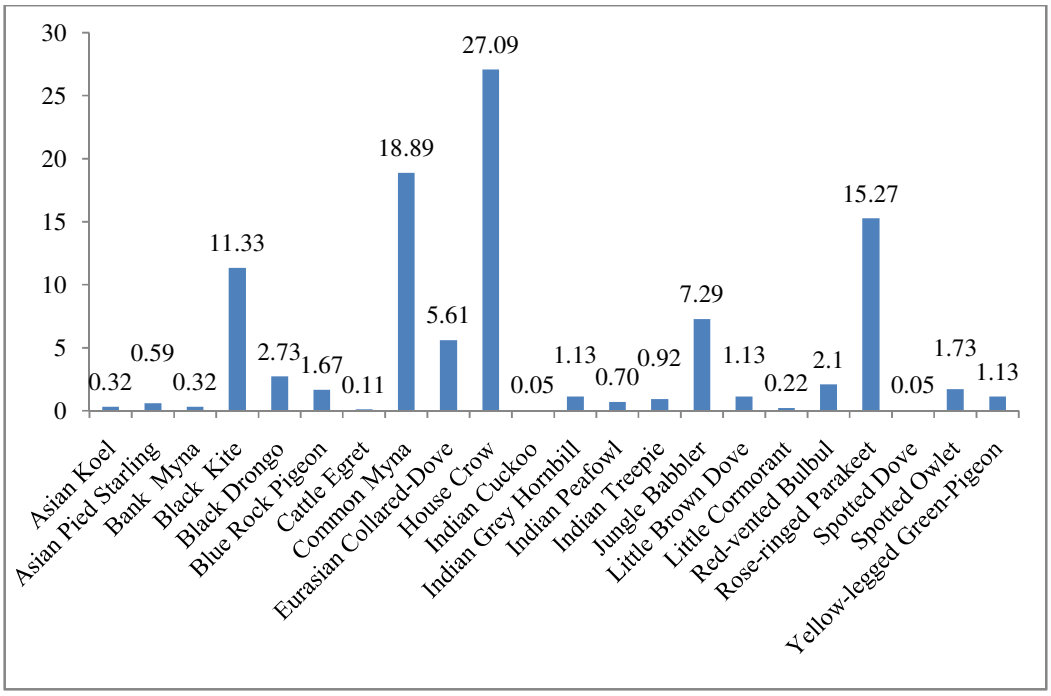

Fig.1: Annual abundance of bird species on Banyan tree at location I

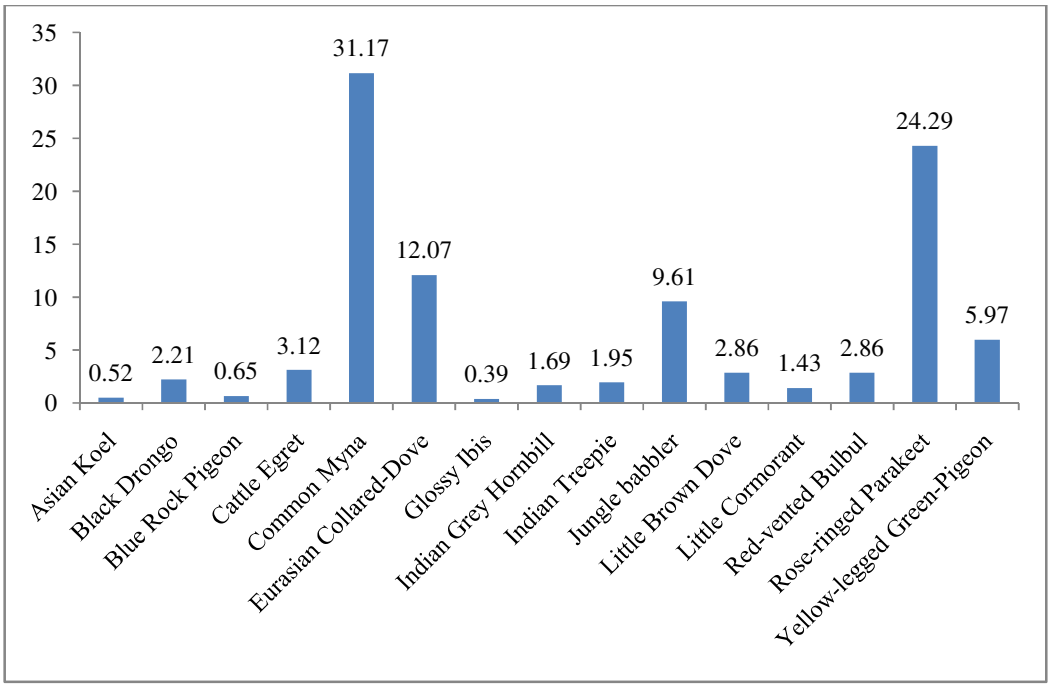

Fig.2: Annual abundance of bird species on Banyan tree at location II

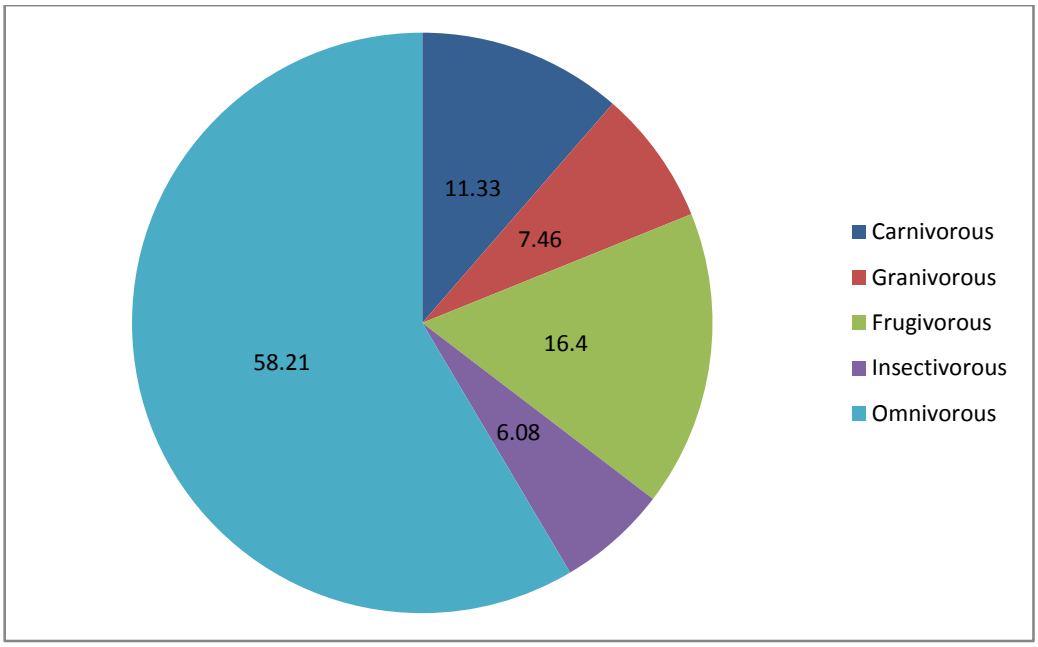

Fig.3: Distribution of bird species according to their feeding habits on Banyan tree at location I

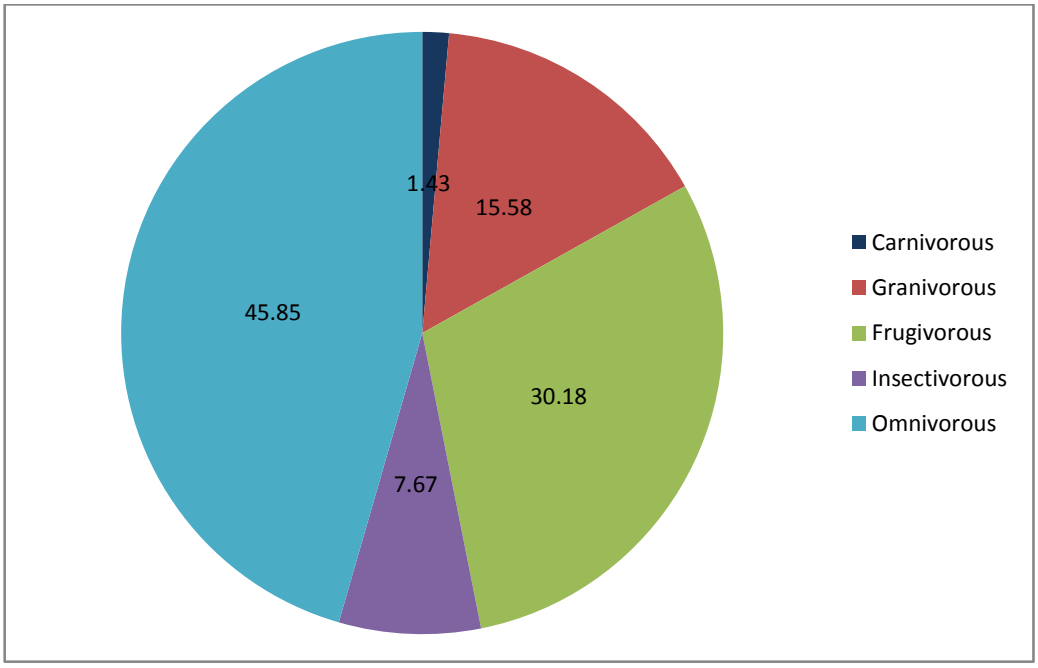

Fig.4: Distribution of bird species according to their feeding habits on Banyan tree at location II

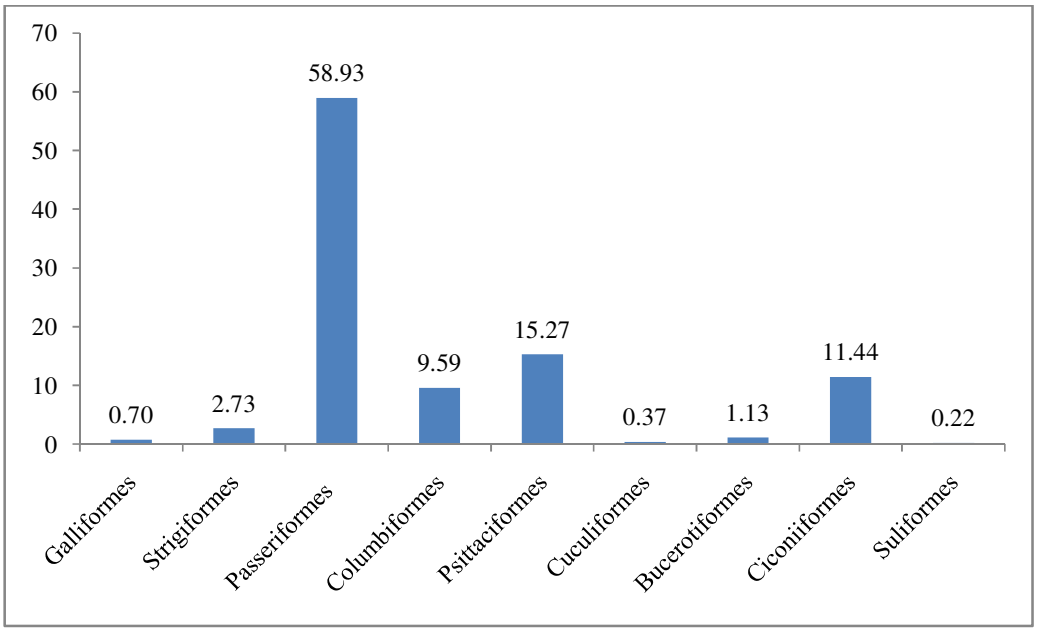

Fig. 5: Distribution of bird species on Banyan tree on the basis of their orders at location I

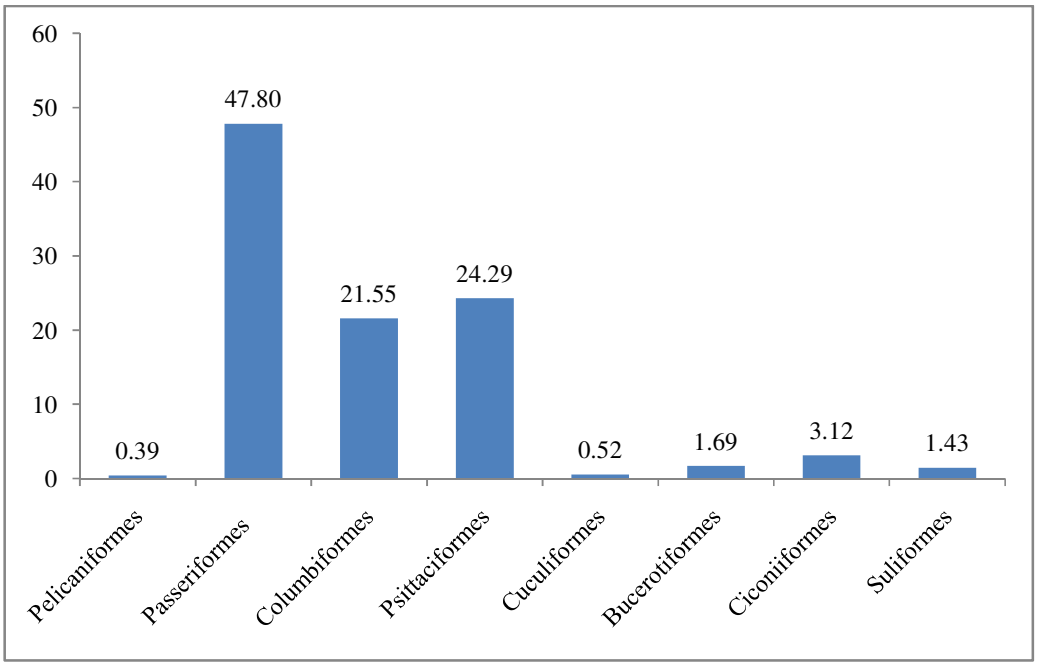

Fig.6: Distribution of bird species on Banyan tree on the basis of their orders at location II

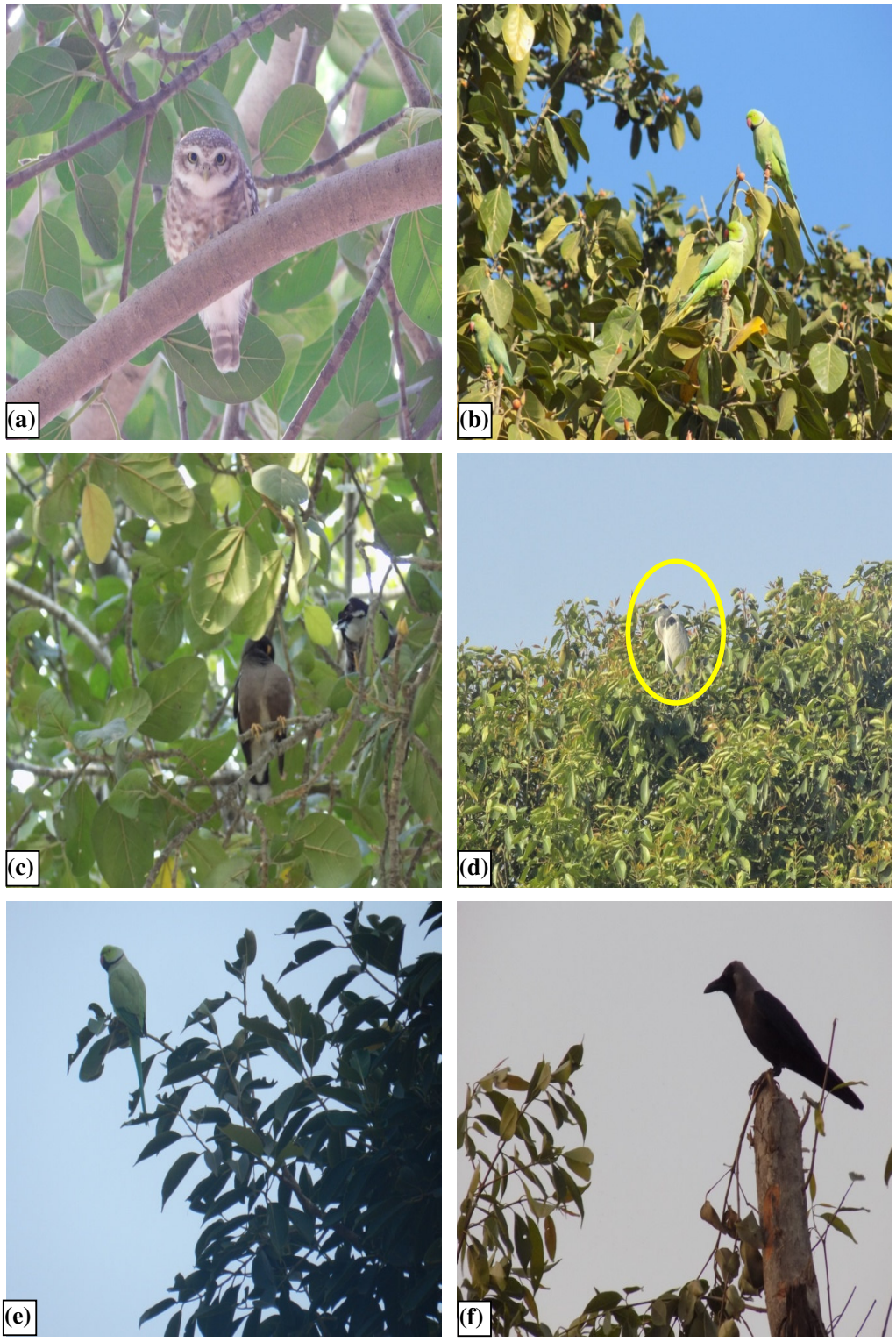

Plate 7 **(a) Spotted Owlet on Banyan tree (b) Rose-ringed Parakeet on Banyan tree (c) Common Myna on Banyan tree (d) Black-crowned Night-Heron on Jamun tree (e) Rose-ringed Parakeet on Jamun tree (f) House Crow on Jamun tree**

insectivorous 7.67 and 45.85 was of omnivorous birds (Fig.4). Annual abundance of frugivorous and omnivorous species were found to be highest at both the locations.

Orders

Bird species of location I belonged to 9 orders i.e Galliformes, Strigiformes, Passeriformes, Columbiformes, Psittaciformes, Cuculiformes, Buceroformes, Ciconiformes and Suliformes (Fig. 5). Annual abundance of bird species belonging to order Passeriformes was found to be highest (58.93) and lowest (0.22) was of order Suliformes.

Bird species of location II belonged to 8 orders i.e. Pelicaniformes, Passeriformes, Columbiformes, Psittaciformes, Cuculiformes, Bucerotiformes, Ciconiformes and Suliformes (Fig 6). Annual abundance of bird species belonging to order Passeriformes was highest (47.80) followed by (24.49) of order Pssitaciformes. Lowest annual abundance (0.39) was of order Cuculiformes.

4.1.2 Jamun (*Syzugium cumini*)

It is also called as Black Plum and belongs to family Myrtaceae. It is a medium sized evergreen tree with dense shady much branched crown. New leaves appear in February and are coppery red in colour. Flowers start appearing from March-April. Ripening of fruits takes place from June -July. Fruits are generally in purplish black in colour with juicy edible pulp.

Location I

Total 16 species of birds were recorded on Jamun tree at location I (Table 6). Species richness was highest in the month of February and March with values 15 and 12 respectively whereas species richness was 5 and 6 in June-July (fruiting period) respectively. This indicates that new foliage and flowering stage of tree attracts more bird species as compared to fruiting stage. Sinu (2012) also reported that jamun attracts a lot of bird diversity. Relative abundance 50.29 and 45.16 of Common Myna was highest in the month of October and September respectively. Relative abundance of House Crow was second highest 44.32 in the month of July. Species diversity was highest (2.07) in month of February and 1.93 in March. Highest species evenness 0.83 was recorded in the month of January and 0.80 in month of December. Annual abundance 36.16 of Common Myna was found to be highest and 24.27 of House Crow was found to be second highest. Lowest annual abundance 0.07 was of Black-crowned Night-Heron followed by 0.14 of Greater Coucal (Plate 7, 8).

Location II

Total 13 species of birds were recorded on Jamun tree at location II (Table 7). Species richness 10 was highest in the month of February, March and April. During these months new foliage appears and flowering occurs which attracts more bird species then the fruiting period of Jamun. Fruiting on Jamun takes place from June to July and species richness during these months was 5 and 6 respectively. Species richness was higher at stage

Table 6: Relative abundance of bird species on Jamun tree at location I from April 2016 - March 2017

Sr. No.	Months → Birds ↓	April	May	June	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	March	Annual abundance
1.	Black Drongo	2.95	0.70	-	-	0.69	1.93	2.95	2.22	2.08	5.55	1.92	5.55	2.19
2.	Black Kite	2.36	2.83	6.87	2.06	1.38	-	0.59	-	-	-	3.84	5.55	2.41
3.	Black-crowned Night-Heron	-	-	-	-	-	-	-	-	-	-	0.96	-	0.07
4.	Blue Rock Pigeon	-	-	-	-	-	-	1.18	1.11	2.08	-	0.96	-	0.35
5.	Common Golden-backed Woodpecker	-	-	-	-	-	-	-	-	-	5.55	0.96	-	0.21
6.	Common Myna	34.31	31.20	31.29	25.77	41.66	45.16	50.29	38.88	35.41	27.77	29.80	29.16	36.16
7.	Eurasian Collared Dove	4.73	5.67	1.52	7.21	5.55	6.45	4.73	4.44	2.08	2.77	4.80	8.33	4.60
8.	Greater Coucal	-	-	-	-	-	-	-	1.11	-	-	0.96	-	0.14
9.	House Crow	21.30	30.49	39.69	44.32	26.38	17.41	12.42	24.44	25	16.66	19.23	20.13	24.27
10.	Jungle Babbler	26.03	17.73	10.68	7.21	20.83	24.51	19.52	25.55	14.58	2.77	13.46	20.83	18.83
11.	Little Brown Dove	1.18	2.83	-	1.03	0.69	0.64	2.36	1.11	-	-	1.92	2.77	1.42
12.	Red-vented Bulbul	2.36	1.41	1.52	1.03		0.64	1.77	-	-	2.77	3.84	2.77	1.56
13.	Rose-ringed Parakeet	2.95	4.25	3.81	2.06	0.69	3.22	2.36	-	6.25	2.77	14.42	2.77	4.39
14.	Small Bee-eater	1.77	2.83	4.58	9.27	2.08	-	-	-	-	-	-	-	1.84
15.	White-breasted Kingfisher	-	-	-	-	-	-	-	1.11	-	-	1.92	0.69	0.28
16.	Yellow-legged Green-Pigeon	-	-	-	-	-	-	1.77	-	12.5	8.33	0.96	0.69	0.99
	Richness	10	10	8	9	9	8	11	9	8	9	15	12	
	Diversity	1.70	1.72	1.54	1.56	1.44	1.43	1.57	1.48	1.67	1.83	2.07	1.93	
	Evenness	0.73	0.75	0.74	0.71	0.65	0.69	0.65	0.67	0.80	0.83	0.76	0.78	

Table 7: Relative abundance of bird species on Jamun tree at location II from April 2016 - March 2017.

Sr. No	Months → / Birds ↓	April	May	June	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	March	Annual abundance
1.	Barn Owl	1.35	-	-	-	-	-	-	-	-	-	-	2.08	0.30
2.	Black Drongo	2.70	4.00	6.66	5.12	-	4.74		3.70		5.40	3.33	4.16	3.15
3.	Common Golden-backed Woodpecker	-	-	-	-	-	-	-	-	-	-	3.33	-	0.30
4.	Common Myna	43.24	45.33	37.77	35.89	58.20	30.43	60.18	55.55	44.44	27.02	33.33	37.5	45.65
5.	Eurasian Collared-Dove	2.70	-	6.66	-	-	5.79	8.33	1.85	-	5.40	3.33	4.16	1.50
6.	Greater Coucal	2.70	-	-	-	-	-	-	-	-	-	-	2.08	0.45
7.	House Crow	-	-	-	-	-	-	-	-	-	-	-	4.16	0.30
8.	Jungle Babbler	28.37	28.00	15.55	25.64	29.85	36.23	19.44	16.66	22.22	5.40	6.66	20.83	23.12
9.	Little Brown Dove	2.70	-	-	7.69		2.89		3.70			1.66	-	1.50
10.	Red-vented Bulbul	1.35	-	-	10.25	5.97	10.14	9.25	1.85	11.11	16.21	15.00	4.16	7.21
11.	Rose-ringed Parakeet	13.51	22.66	33.33	15.38	5.97	10.14	2.77	16.66	11.11	29.72	25.00	18.75	14.86
12.	White-breasted Kingfisher	-	-	-	-	-	-	-	-	-	-	5.00	2.08	0.60
13.	Yellow-legged Green-Pigeon	1.35	-	-	-	-	-	-	-	11.11	10.81	3.33	-	1.51
	Richness	10	4	5	6	4	7	5	7	5	7	10	10	
	Diversity	1.55	1.18	1.38	1.58	1.01	1.59	1.15	1.31	1.42	1.72	1.84	1.78	
	Evenness	0.67	0.85	0.86	0.88	0.73	0.82	0.71	0.67	0.88	0.88	0.80	0.77	

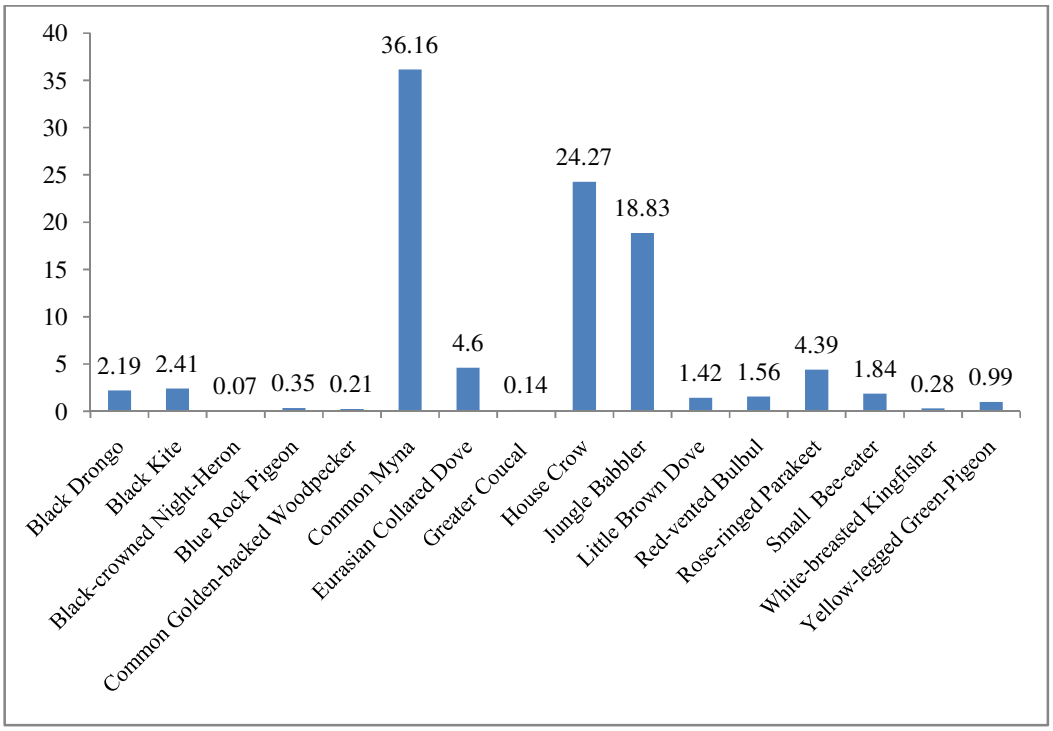

Fig 7: Annual abundance of bird species on Jamun tree at location I

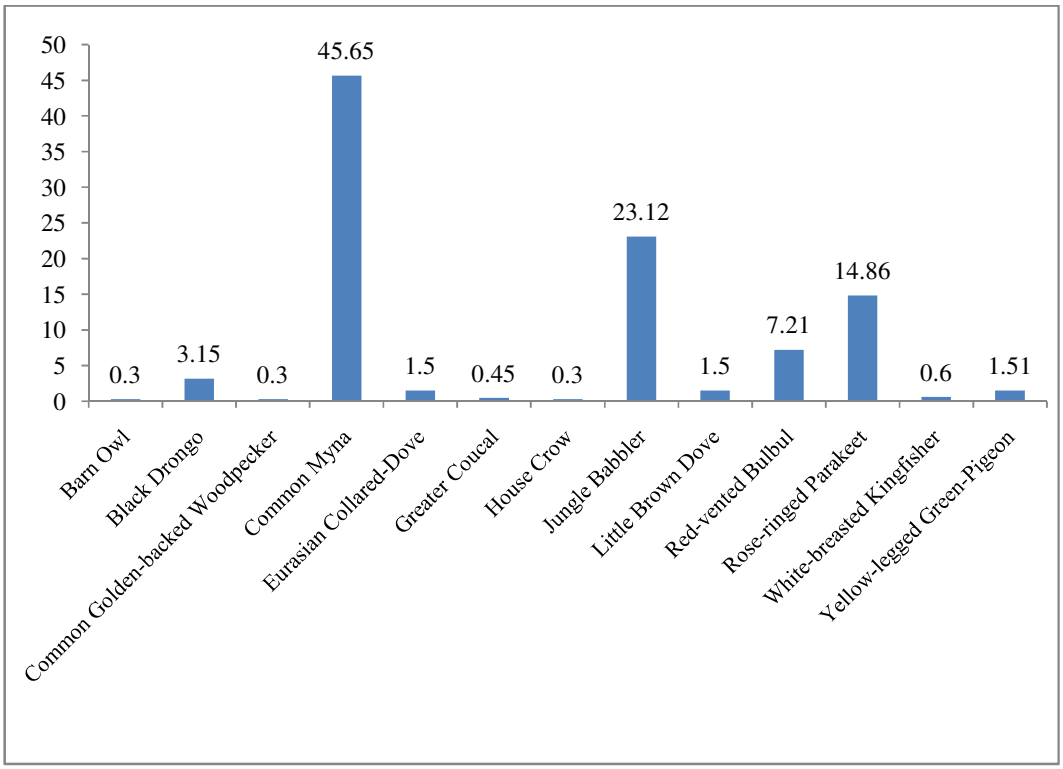

Fig 8: Annual abundance of bird species on Jamun tree at location II

when new foliage appears and at flowering stage as compared to fruiting stage. Lowest species richness (4) was recorded in both the months July and August. Relative abundance of Common Myna 60.18 in month of October and 58.20 in the month of August was recorded to be highest. It was lowest (1.35) and equal of Barn Owl and Yellow legged Green-Pigeon in the month of April. Species diversity was highest 1.84 in the month of February followed by 1.78 in the month of March. Species evenness was highest and equal (0.88) in all the three months July, December and January and second highest 0.86 was in the month of June. Maximum annual abundance 45.64 was of Common Myna, followed by 23.12 of Jungle Babbler. Lowest annual abundance 0.05 of Yellow-footed Green-Pigeon was recorded.

Feeding habits

At location I annual abundance (60.4) of omnivorous bird species was found to be maximum followed by granivorous 23.78, insectivorous 7.71, frugivorous 5.38 and 2.41 was least of carnivorous bird species (Fig. 9). At location II highest annual abundance 65.95 was of omnivorous bird species (Fig. 10). Annual abundance of frugivorous species was 16.16 and Insectivorous 13.51. Least annual abundance (0.30) was of carnivorous bird species followed by 4.62 of granivorous species. Omnivorous birds were dominant at both the locations.

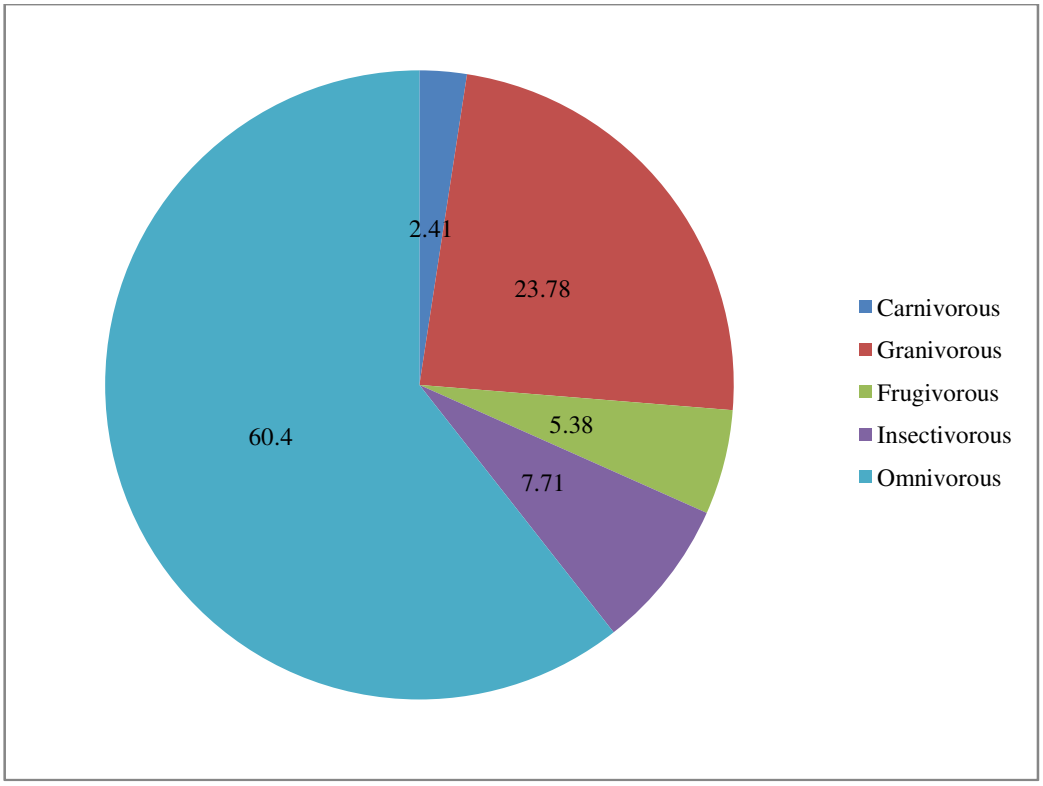

Fig 9: Distribution of bird species according to their feeding habits on Jamun tree at location I

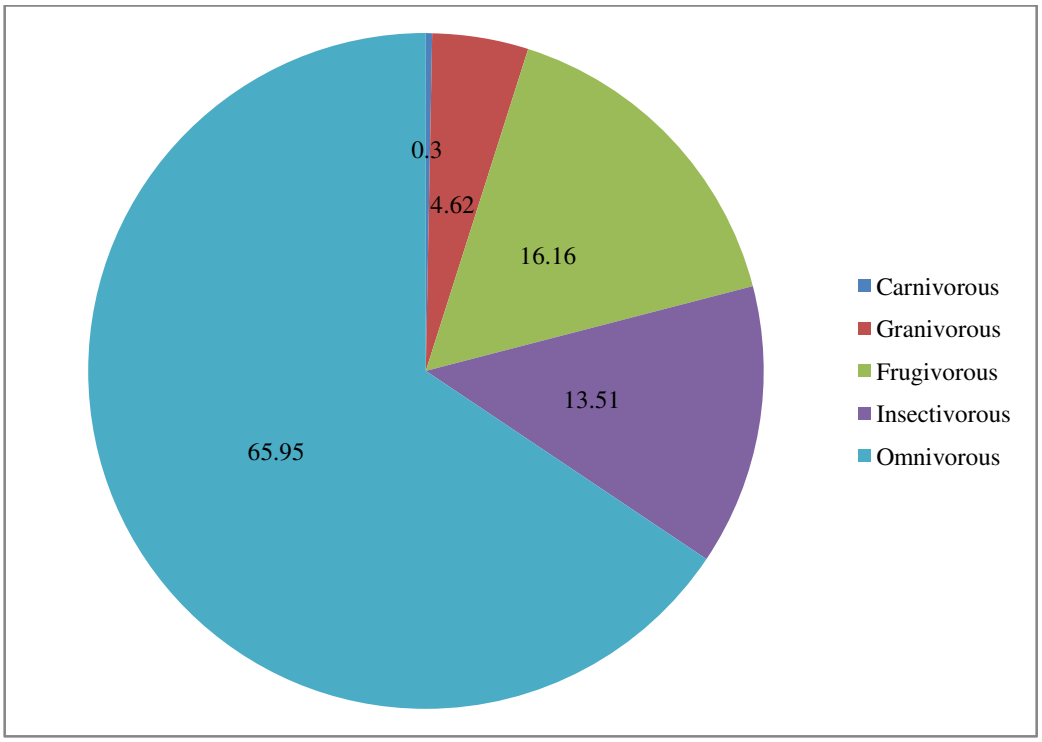

Fig. 10: Distribution of bird species according to their feeding habits on Jamun tree at location II

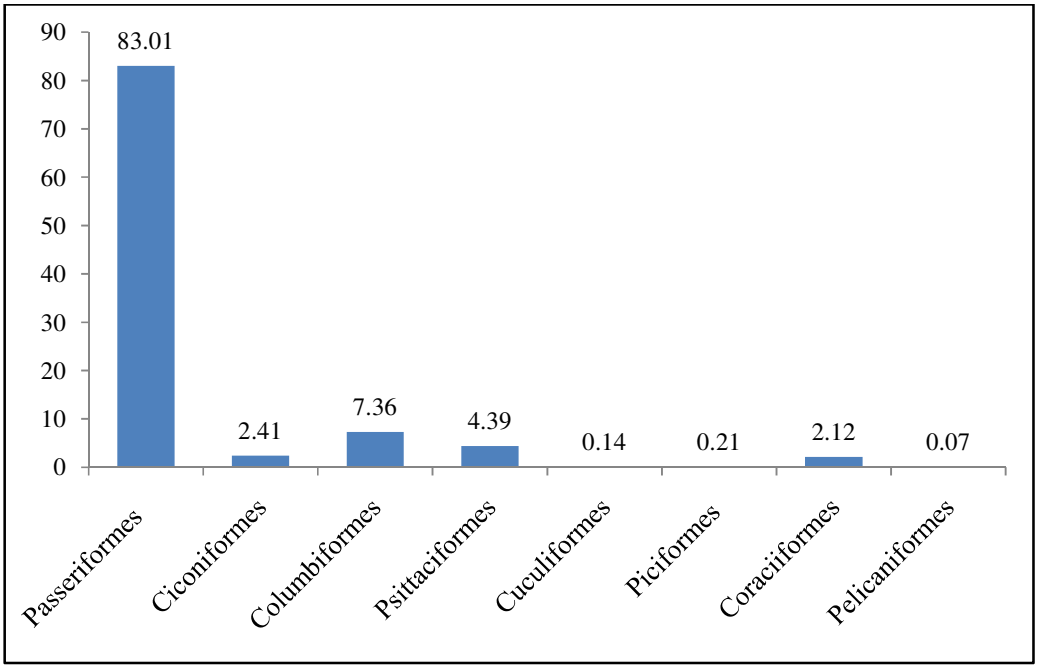

Fig.11: Distribution of bird species on Jamun tree on the basis of their orders at location I

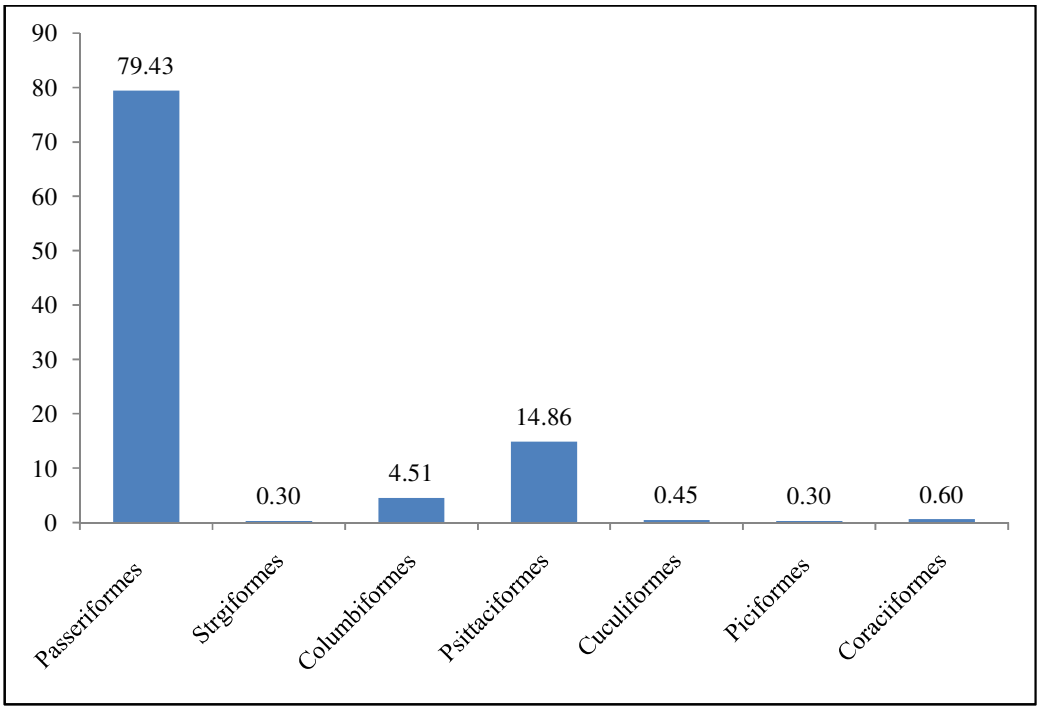

Fig.12: Distribution of bird species on Jamun tree on the basis of their orders at location II

Orders

At location I bird species found on Jamun tree belonged to 8 orders (Fig. 11). Bird species belonging to order Passeriformes were most dominant with annual abundance 83.01. Annual abundance of order Columbiformes was 7.36, Ciconiformes 2.41, Psiitaciiformes was 4.39 and 2.12 was of Coraciformes. Lowest annual abundance (0.07) was of order Pelicaniformes followed by 0.14 of Cucliformes and 0.21 of Piciformes.

Bird species recorded at location II belonged to 7 orders (Fig. 12). Bird species belonging to order Passeriformes were most dominant with 79.43 annual abundance. Annual abundance of order Psittaciformes was 14.88 and 4.51 was of order Columbiformes. Abundance of order Stigiformes, Cuculiformes, Piciformes and Coraciformes was recorded 0.30, 0.45. 0.30 and 0.60 respectively.

4.1.3 Mulberry (*Morus alba*): Mulberry is a medium sized fruiting tree. Trees are bare in the month of January till the first week of February. New foliage starts appearing in the last week of February. Fruiting takes place in the month of March.

Location I

Total 30 species of birds were recorded on Mulberry tree at location I (Table 8). Highest species richness (22) was recorded in both the months February and March. Second highest species richness 20 was recorded in the month of April. Lowest species richness 8 was recorded in the month of December. Highest relative abundance 40.22 and 36.84 was of

Table 8: Relative abundance of bird species mulberry tree at location I from April 2016 – March 2017

	Months → Birds ↓	April	May	June	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	March	Annual abundance
1.	Asian Koel	2.19	-	-	-	-	-	1.08	-	-	-	-	-	0.37
2.	Asian Pied Starling	2.19	-	3.35	-	-	-	-	-	-	-	-	3.58	1.05
3.	Bank Myna	-	-	-	-	-	-	3.26	-	-	-	1.09	-	0.31
4.	Bay-backed Shrike	1.09	0.66	-	-	-	-	-	-	-	-	-	-	0.18
5.	Black Drongo	1.64	0.66	3.91	1.14	1.50	2.29	2.17	2.94	1.72	2.67	1.63	2.05	1.66
6.	Black Redstart	-	-	-	-	-	-	-	1.47	-		0.54	1.53	0.31
7.	Brahaminy Starling	-	-	-	-	-	-	3.26	5.88	-	4.46	4.37	2.05	1.17
8.	Brown-headed Barbet	0.54	-	-	-	-	-	-	-	-	-	-	-	0.06
9.	Common Myna	11.53	30.66	34.07	30.84	36.84	40.22	31.52	32.35	20.68	25.00	16.39	17.43	26.15
10.	Common Starling	-	-	-	-	-	-	-	-	-	-	4.37	3.07	0.86
11.	Common Tailorbird	-	3.33	0.55	-	0.75			5.88	5.17	2.67	3.82	1.53	1.29
12.	Eurasian Collared-Dove	1.64	2.66	3.35	5.14	6.01	5.34	6.52	4.41	3.44	4.46	1.63	2.56	3.63
13.	Greater Coucal	-	-	-	-	-	-	1.08	-	-	-	1.09	1.02	0.31
14.	Green Bee-eater	3.84	3.33	3.35	-	-	-	-	-	-	-	3.27	6.15	1.91
15.	Grey Wagtail	-	-	-	-	-	-	-	-	-	-	2.18	3.07	0.62
16.	House Crow	5.49	4.46	2.79	2.85	2.25	2.29	3.26	-	-	5.35	2.73	2.56	3.51
17.	Indian Grey Hornbill	1.64	-	-	0.57	2.25	-	-	4.41	-	-	2.18	1.53	1.05
18.	Indian Roller	-	-	-	-	-	-	-	-	-	-	1.63	0.51	0.25
19.	Indian Treepie	1.64	-	-	2.85	-	-	-	4.41	-	0.89	-	-	0.74
20.	Jungle Babbler	21.97	27.33	26.25	31.42	26.31	22.98	18.47	17.64	6.89	3.57	8.19	11.28	19.82
21.	Little Brown Dove	2.74	2.00	2.79	4.57	0.75	6.89	5.43	5.88	6.89	2.67	1.09	1.53	3.38

22.	Oriental Magpie-Robin	2.19	-	-	-	-	-	-	-	-	-	-	-	0.25
23.	Pied Crested Cuckoo	-	-	-	-	-	-	2.17	-	-	-	-	-	0.12
24.	Pied Wagtail	-	-	-	-	-	-	-	-	-	-	1.63	2.05	0.43
25.	Purple Sunbird	3.84	-	3.35	-	-	-	-	-	-	-	-	2.05	1.05
26.	Red-vented Bulbul	1.09	0.66	-	-	2.25	3.44	3.26	1.47	-	2.67	1.63	0.51	1.60
27.	Rose-ringed Parakeet	18.68	15.33	15.64	17.71	15.78	10.34	13.04	8.82	39.68	38.39	29.50	22.05	20.12
28.	Spotted Owlet	3.84	4.46	0.55	2.85	5.26	5.74	5.43	4.41	-	2.67	2.18	3.07	3.26
29.	Yellow Wagtail	1.64	-	-	-	-	-	-	-	-	-	2.18	-	0.43
30.	Yellow-legged Green-Pigeon	10.43	4	-	-	-	-	-	-	15.51	3.57	6.55	8.71	4.12
	Richness	20	13	12	10	11	9	14	13	8	13	22	22	
	Diversity	2.48	1.92	1.84	1.71	1.72	1.74	2.14	2.16	1.69	1.93	2.49	2.57	
	Evenness	0.82	0.74	0.74	0.74	0.72	0.79	0.81	0.84	0.81	0.75	0.80	0.83	

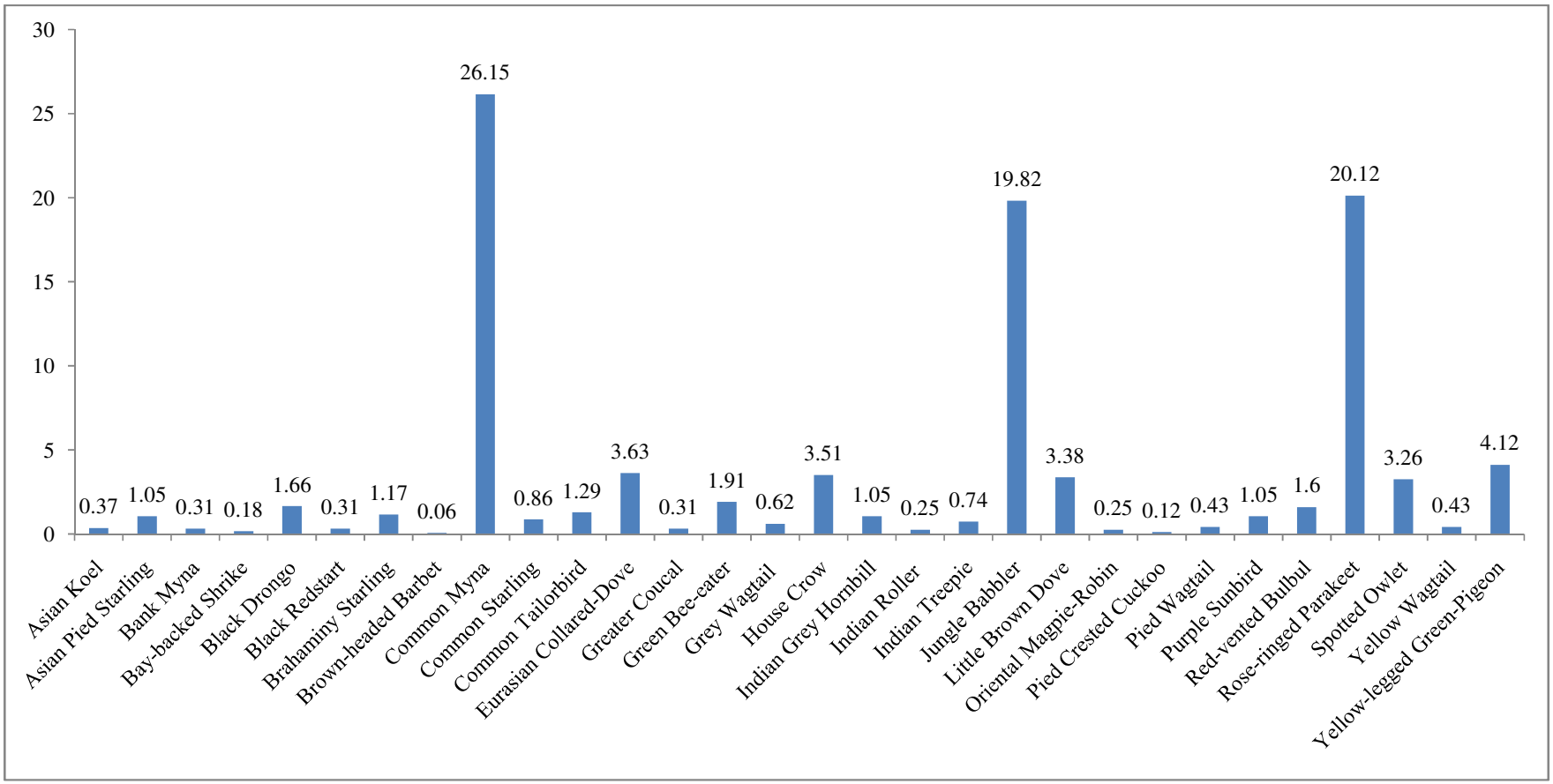

Fig. 13: Annual abundance of bird species on Mulberry tree at location I

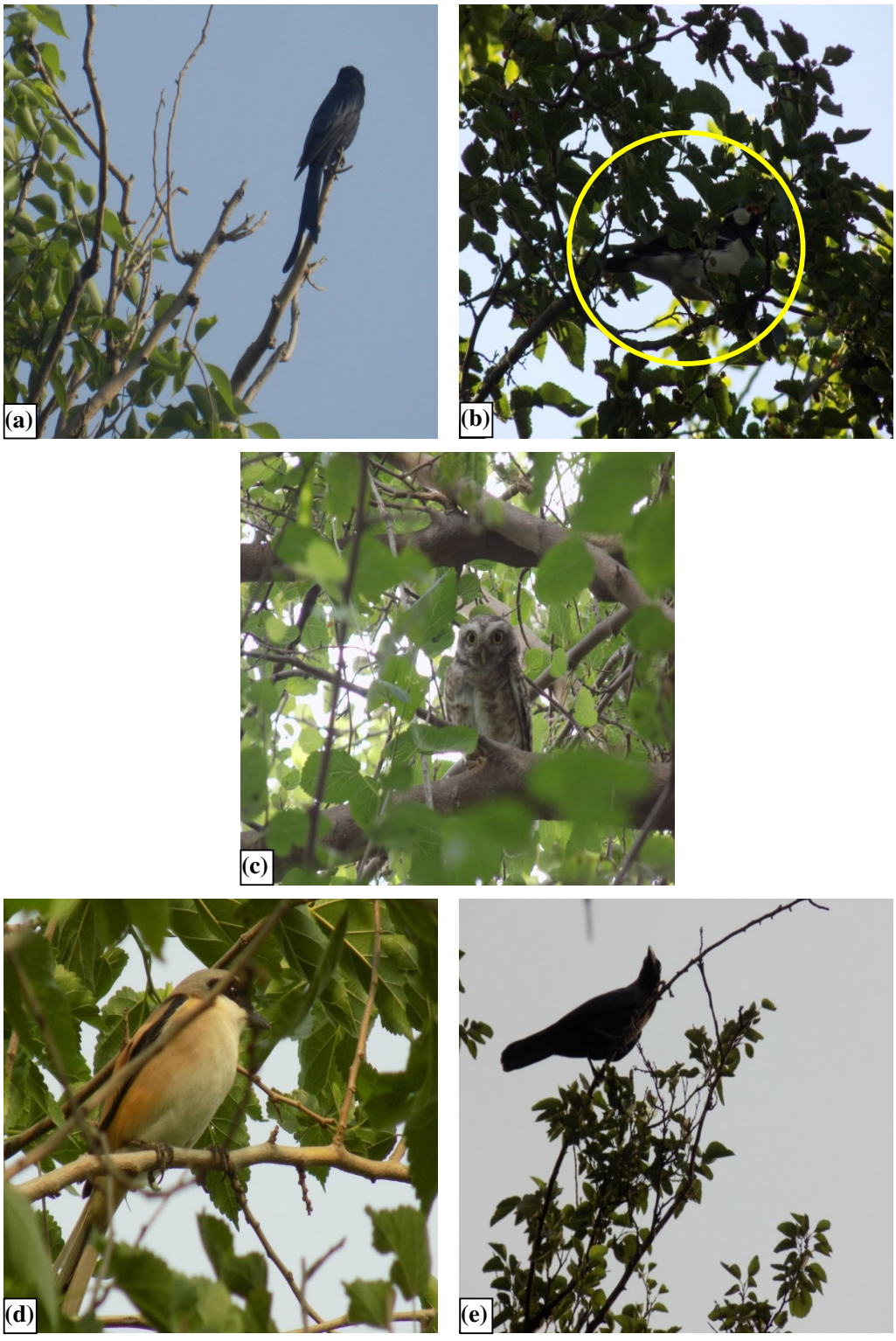

Plate 8: **(a) Black Drongo on Jamun tree (b) Asian Pied Starling on Mulberry tree (c) Spotted Owlet on Mulberry tree (d) Bay-backed Shrike on Mulberry tree (e) House Crow on Mulberry tree**

Table 9: Relative abundance of bird species on Mulberry tree at location II from April 2016 – March 2017

Sr. No	Months → Birds ↓	April	May	June	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	March	Annual abundance
1.	Asian Koel	-	0.70	-	-	-	-	-	-	-	-	-	2.20	0.59
2.	Bank Myna	2.38	-	-	-	-	-	-	9.52	-	-	-	2.82	1.13
3.	Black Drongo	1.78	2.83	0.74	1.49	3.09	1.08	6.38	4.76	-	-	3.87	1.69	2.50
4.	Black Redstart	-	-	-	-	-	-	-	-	-	-	1.55	-	0.15
5.	Common Myna	21.42	16.31	29.85	36.56	37.11	42.39	42.55	36.50	15.38	2.53	11.62	10.73	24.94
6.	Common Tailorbird	4.76	8.83	-	0.74	-	3.26	1.06	-	-	-	0.77	0.56	0.66
7.	Eurasian Collared-Dove	2.38	2.83	4.47	5.22	8.24	7.60	7.44	7.93	2.56	10.12	3.87	1.69	4.78
8.	Greater Coucal	-	-	-	-	-	-	-	1.58	-	-	-	0.56	0.15
9.	Green Bee-eater	4.76	5.67	2.23	-	-	-	-	-	-	-	5.42	4.51	2.94
10.	Indain Shikra	-	-	-	-	-	1.08	-	-	-	-	-	-	0.07
11.	Indian Chat	-	-	-	-	-	-	2.12	-	-	-	2.32	-	0.74
12.	Indian Cuckoo	-	-	0.74		-	-	-	-	-	-	-	-	0.07
13.	Indian Grey Hornbill	-	0.70	-	-	3.09	5.43	-	-	-	1.26	4.65	3.38	1.62
14.	Indian Roller	1.19	-	-	-	-	-	1.06	-	-	-	-	-	0.22
15.	Indian Treepie	1.78	-	-	-	-	3.26		-	5.12	-	2.32	-	0.81
16.	Jungle Babbler	26.19	26.24	32.08	29.85	26.80	15.21	9.57	9.52	10.25	6.32	7.75	13.55	19.28
17.	Little Brown Dove	1.78	2.83	5.22	3.73	3.09	6.52	7.44	6.34	10.25	5.06	1.55	2.55	3.83
18.	Oriental Magpie-Robin	1.78	-	-	-	-	-	-	-	-	-	-	-	0.22
19.	Purple Sunbird	-	3.54	3.73	-	-	-	-	-	-	-	-	1.69	0.09
20.	Red-vented Bulbul	1.19	2.12	0.74	0.74	1.03	1.08	6.38	-	-	3.79	1.55	1.12	1.91
21.	Rose-ringed Parakeet	20.83	17.73	14.17	16.41	12.37	11.95	11.70	20.63	43.58	51.89	38.75	28.24	22.52
22.	Spotted Owlet	4.16	4.96	5.97	5.22	5.15	1.08	4.25	3.17	2.56	-	3.87	2.82	4.05
23.	Yellow-legged Green-Pigeon	3.57	10.63	-	-	-	-	-	-	10.25	3.79	10.07	22.03	5.89
	Richness	15	14	11	9	9	12	11	9	8	11	15	16	
	Diversity	2.12	2.17	1.78	1.59	1.70	1.85	1.89	1.83	1.69	1.74	2.13	2.14	
	Evenness	0.78	0.82	0.74	0.72	0.77	0.74	0.78	0.83	0.81	0.72	0.78	0.79	

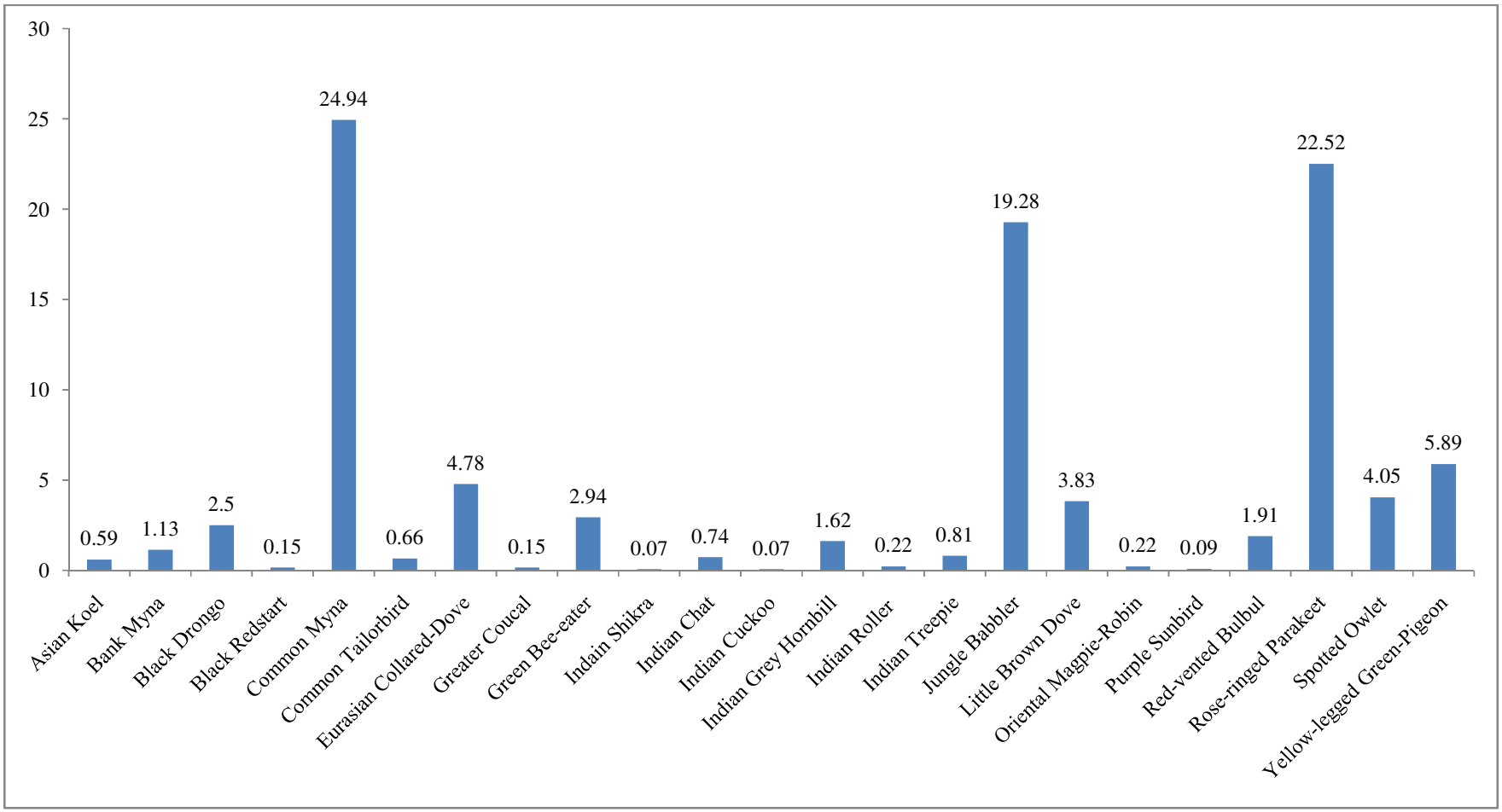

Fig14: Annual abundance of bird species on Mulberry tree at location II

Plate 9: **(a) Rose-ringed Parakeet on Mulberry tree (b) Rose-ringed Parakeet feeding on berries of Mulberry tree (c, d) Yellow-legged Green-Pigeon on Mulberry tree (e) Yellow-legged Green-Pigeon and Rose-ringed Parakeet on Mulberry tree**

Common Myna in the month of September and August respectively. Lowest relative abundance 0.51 was of Indian Roller and Red-vented Bulbul in the month of March. Highest species diversity 2.57 was recorded in the month of March and second highest species evenness 2.49 was recorded in the month of February. Aslan and Rejmanek (2010) stated that *Morus* sp. are favourite spot for birds for perching and eating. It was lowest 1.69 in the month of December. Species evenness was recorded to be highest 0.84 in the month of November and 0.83 in the month of March. It was lowest 0.72 in the month of August. Annual abundance of Common Myna 26.12 was recorded to be highest. Second highest Annual abundance 20.09 was of House Crow. Lowest annual abundance 0.06 was of Brown-headed Barbet followed by 0.17 was of Brahaminy Starling (Plate 8, 9).

Location II

Total 23 species of birds were recorded on Mulberry tree at location II (Table 9). Highest species richness 16 was recorded in the month of March. Second highest species richness 15 was recorded in the months February and April. It was lowest 8 in the month of December. Highest relative abundance 51.89 and 43.58 was of Rose-ringed Parakeet in the months January and December. Second highest relative abundance of Common Myna 42.55 and 42.39 was in the months October and September respectively. Lowest relative abundance 0.56 was of Greater Coucal and Common Tailorbird in the month of March. Highest species diversity was recorded to be 2.17 in the month of May. Second highest species diversity 2.14 was recorded in the month of March. It was lowest (1.69) in the month of December. Species evenness was highest (0.83) in the month of November. It was second highest (0.82) in the month of May. It was lowest (0.72) in months July and January. Annual abundance of Common Myna (24.94) was highest. Second highest annual abundance (22.52) was of Rose-ringed Parakeet. It was lowest (0.05) of Spotted Owlet (Plate 8, 9).

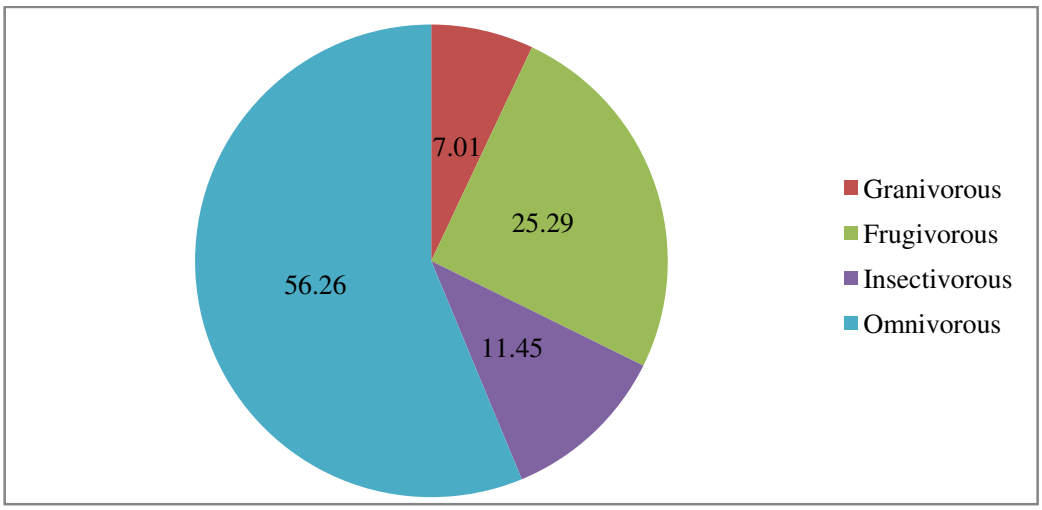

Fig.15: Distribution of bird species according to their feeding habits on Mulberry tree at location I

Feeding habits

Birds recorded on Mulberry tree at location I belonged to four categories on the basis of their feeding habits i.e. omnivorous, frugivorous, insectivorous and granivorous (Fig.15). Among these four categories, omnivorous birds species were most dominant with annual abundance 56.26 followed by 26.29 of frugivorous species. Abundance of insectivorous species was 11.45 and of granivorous species was 7.01.

At location II abundance of omnivorous species was found to be highest (38.48) followed by 28.50 of frugivorous bird species (Fig. 16). Abundance of insectivorous and granivorous species was 13.71 and 8.61 respectively.

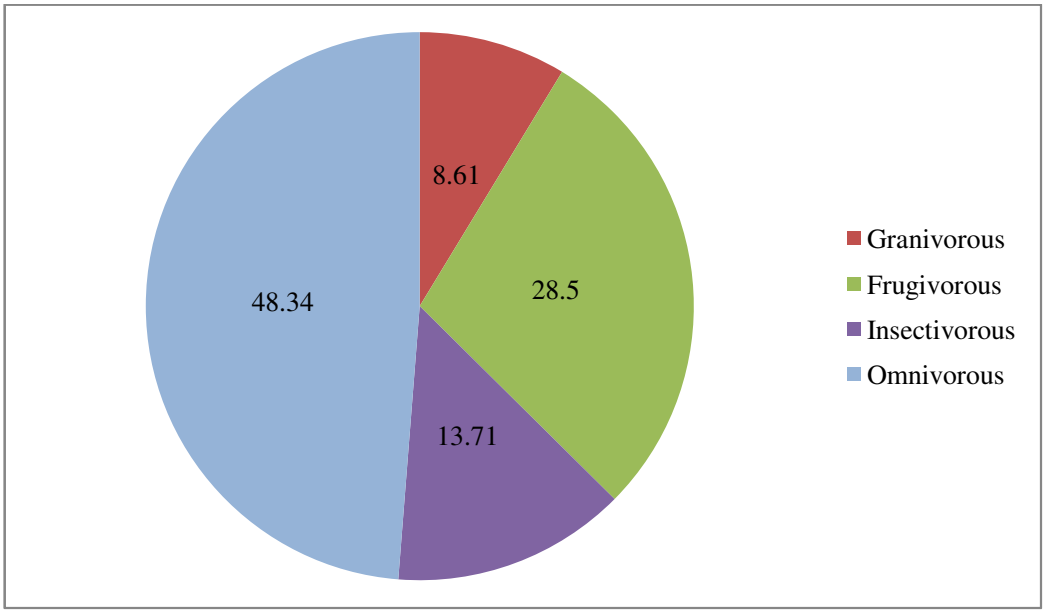

Fig.16: Distribution of bird species according to their feeding habits on Mulberry tree at location II

Orders

Birds recorded on Mulberry tree at location I belonged to 7 orders. Bird species belonging to order Passeriformes were most abundant (59.83) (Fig 17). Abundance of other orders Strigiformes, Columbiformes, Cuculiformes, Bacerotiformes, Piciformes and Coraciformes was 3.26, 11.13, 0.80, 1.05, 0.06 and 2.16 respectively.

At location II birds belonged to 8 orders (Fig. 18). Birds belonging to order Passeriformes were most dominant (52.43) followed by abundance 22.52 of Psittaciformes. Abundance of order Columbiformes, Cuculiformes, Bucerotiformes, Coraciformes, Acciptriformes and Strigiformes was 14.50, 0.81, 1.62, 3.16, 0.07 and 4.05 respectively**.**

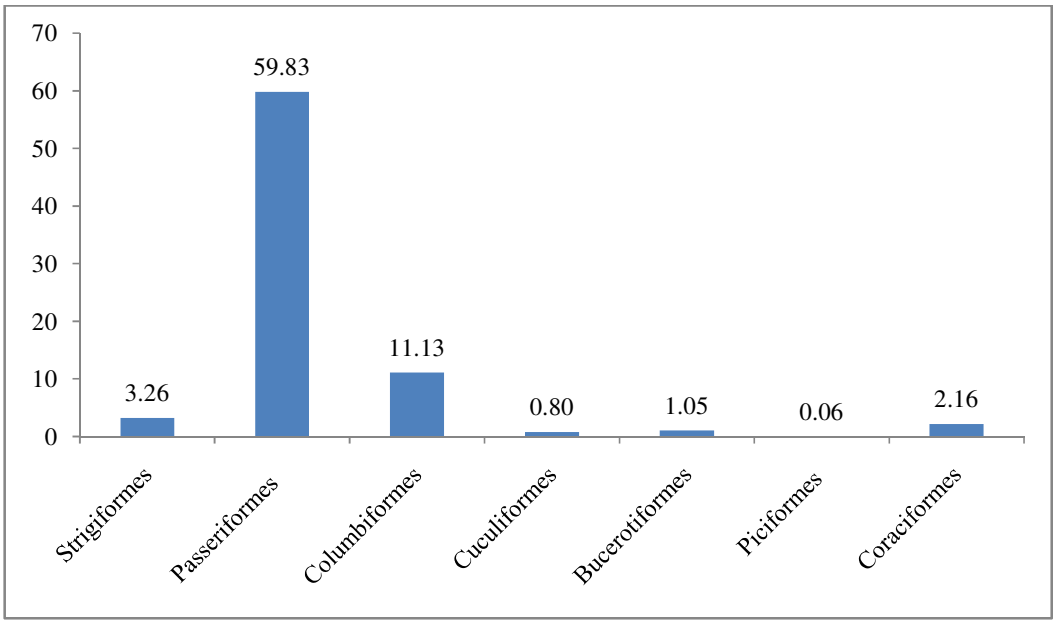

Fig.17: Distribution of bird species on Mulberry tree on the basis of their orders at location I

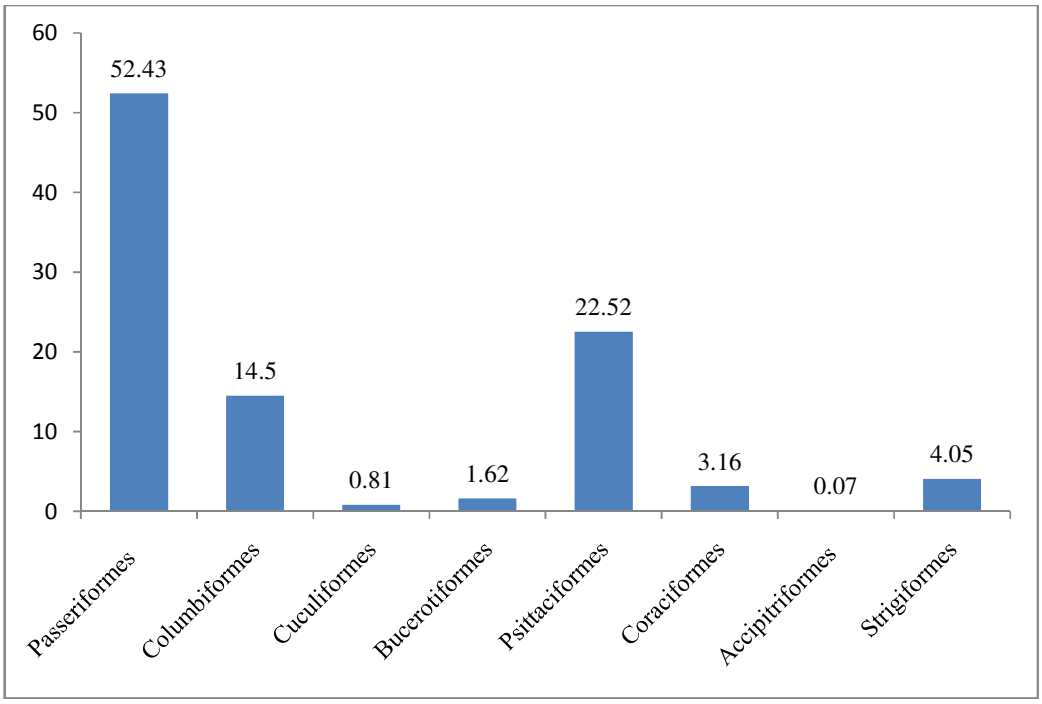

Fig.18: Distribution of bird species on Mulberry tree on the basis of their orders at location II

4.1.4 Neem (*Azadirachta indica*)

Neem tree belongs to family Meliaceae. Its fruits and seeds are the source of neem oil. Neem is a fast-growing tree that can reach a height of 15–20 meters. It is evergreen, but in

severe drought it may shed most or nearly all of its leaves. Shedding of leaves takes place in the month of January. The branches are wide and spreading. The fairly dense crown is roundish. New foliage appears in month of February. The (white and fragrant) flowering occurs in the month of March and fruiting starts in the beginning of April. The fruit is a smooth (glabrous) and olive-like.

Location I

Total 18 species of birds were recorded at location I (Table 10). Species richness was recorded to be highest in the month of March (15) which was a flowering period. Second highest species richness (14) was recorded in the month of February. Relative Abundance of Common Myna was highest 42.50 and 39.90 in the months July and October respectively. Least relative abundance (0.48) was of birds Common Golden-backed Woodpecker, Jungle Babbler, Little Brown Dove and White-breasted Kingfisher in the month of March. Highest species diversity (2.44) was recorded in the month of February followed by 2.19 in the month of March. It was recorded to be lowest (1.63) in the month of December. Highest species evenness (0.84) was recorded in the month of May. Second highest species evenness (0.83) was recorded in both the months December and January. Annual abundance of Common Myna (28.06) was found to highest followed by Rose-ringed Parakeet with second highest annual abundance (23.91). Common Golden-backed Woodpecker and White-breasted Kingfisher both shows the lowest (0.20) annual abundance (Plate 10, 11).

Location II

Total 22 species of birds were found at this location (Table 11). Species richness was recorded highest (19) in the month of March (new foliage stage) followed by 14 in April (fruiting Stage). It was found to be lowest (6) in the month of December. Highest relative abundance 68.00 and 62.96 of Common Myna was recorded in the month of December and November. Least relative abundance 0.52 was of birds Greater Coucal and Spotted Owlet in the month of April. Second lowest relative abundance (0.72) was of White-breasted Kingfisher in the month of May. Species diversity was found to be highest (2.45) in the month of February. Second highest (2.45) was in month of March. Lowest species diversity (1.07) was recorded in the month of December. Species evenness was recorded to be highest (0.89) in the month of January followed by 0.88 in the month of March. Species evenness was recorded lowest (0.57) in the month of November followed by 0.60 in December. Maximum annual abundance 37.31 of Common Myna was recorded. Second highest annual abundance 13.29 was of Rose-ringed Parakeet. Birds like Greater Coucal, Brown Fish-Owl, Common Golden-backed Woodpecker and Common Hoopoe shows the lowest (0.16) annual abundance (Plate 10, 11).

Plate 10: **(a) Greater Coucal on Neem tree (b) Little Brown Dove on Neem tree (c) Red-vented Bulbul on Neem tree (d) Indian Roller on Neem tree, (e) Purple Sunbird (Male) on Neem tree (f) Purple Sunbird (Female) on Neem tree**

Table 10: Relative abundance of bird species on Neem tree at location I from April 2016- March 2017

Sr. No	Months → / Birds ↓	April	May	June	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	March	Annual abundance
1	Asian Koel	1.19	3.02	-	-	-	-	-	-	-	-	-	-	0.47
2	Black Drongo	4.19	9.25	9.89	7.50	3.12	0.86	0.75	1.06	5.26	9.25	10.20	4.39	5.08
3	Common Golden-backed Woodpecker	-	-	-	-	-	-	1.50	-	-	-	-	0.48	0.20
4	Common Hoopoe	0.59	-	-	-	-	1.73	0.75	-	-	-	4.08	-	0.40
5	Common Myna	24.55	23.45	30.76	42.50	32.29	35.65	39.09	37.23	31.57	15.74	2.04	20.48	28.06
6	Common Tailor-bird	6.58	4.32	3.29	2.50	-	0.86	-	-	-	-	11.22	6.34	3.21
7	Eurasian Collared-Dove	5.38	8.64	8.79	2.50	3.12	5.21	5.26	9.57	14.47	6.48	12.24	8.29	7.15
8	Green Bee-eater	5.98	4.32	4.39	3.74	6.25	-	-	-	-	-	-	2.43	2.34
9	House Crow	12.57	16.66	16.48	20.00	26.04	21.73	16.54	22.34	15.78	11.11	2.04	10.24	15.30
10	Indian Grey Hornbill	-	0.61	-	-	-	0.86	2.25	-	-	4.62	6.12	2.92	1.47
11	Indian Treepie	-	-	-	-	-	-	1.50	3.19	-	3.70	7.14	-	1.07
12	Jungle Babbler	-	-	-	5.00	4.16	2.60	0.75	4.25	-	-	5.10	0.48	1.07
13	Little Brown Dove	0.59	3.08	1.09	-	3.12	5.21	3.75	2.12	3.94	2.77	14.28	0.48	2.27
14	Purple Sunbird	5.38	1.85	-	-	-	-	-	-	-	-	-	4.39	1.40
15	Red-vented Bulbul	6.58	3.70	1.09	1.25	3.12	5.21	6.76	1.06	1.31	0.92	4.08	4.39	3.74
16	Rose-ringed Parakeet	25.14	20.98	24.17	15	18.75	19.13	21.05	18.08	27.63	37.03	6.12	26.34	23.91
17	White-breasted Kingfisher	-	-	-	-	-	0.86	-	-	-	-	1.02	0.48	0.20
18	Yellow-legged Green-Pigeon	1.19	-	-	-	-	-	-	1.06	-	8.33	14.28	7.80	2.67
	Richness	13	12	9	9	9	12	12	10	7	10	14	15	
	Diversity	2.09	2.11	1.79	1.67	1.76	1.80	1.77	1.70	1.63	1.91	2.44	2.19	
	Evenness	0.81	0.84	0.81	0.76	0.80	0.72	0.71	0.74	0.83	0.83	0.92	0.81	

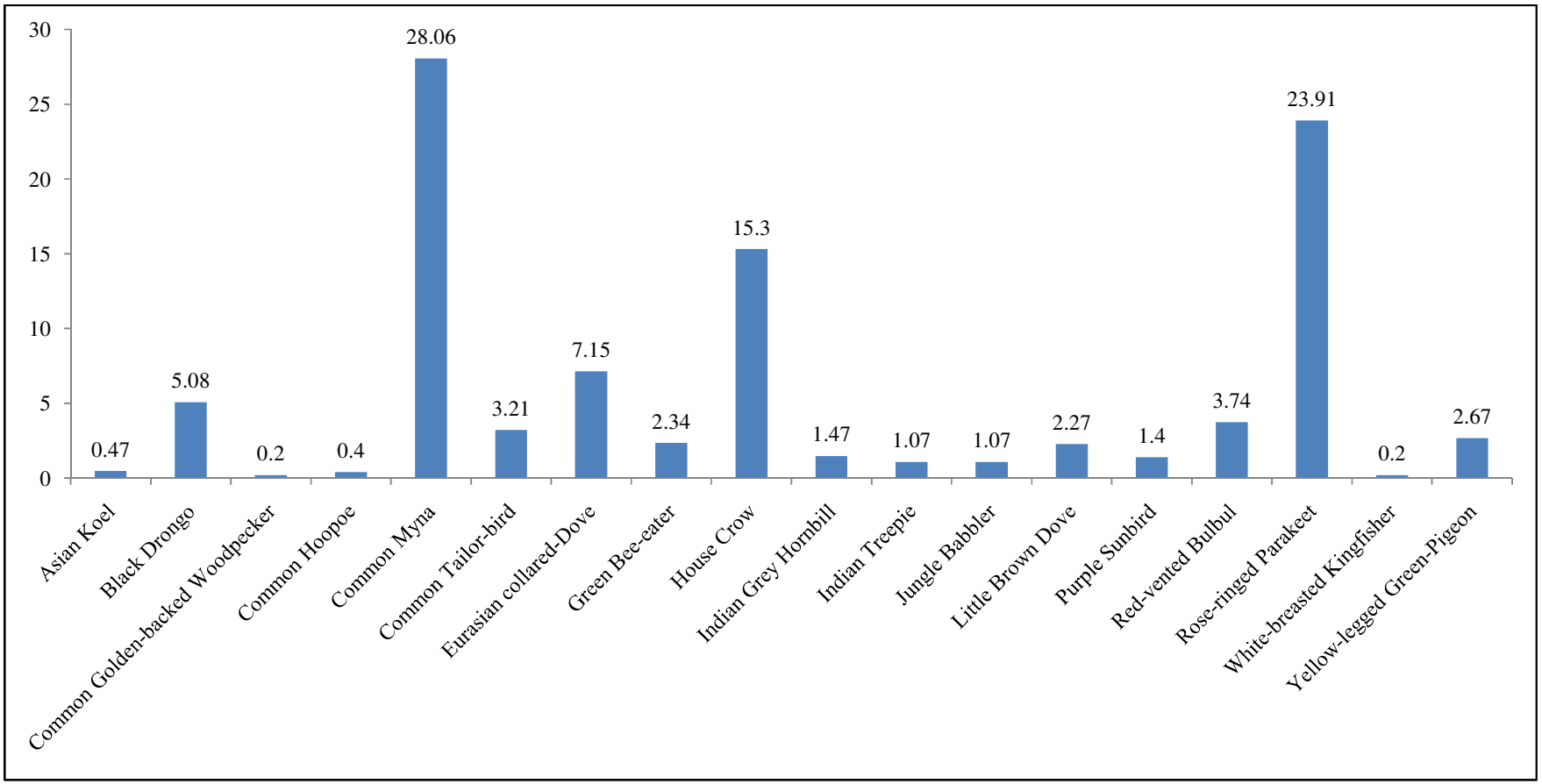

Fig.19: Annual abundance of birds on Neem tree at location I

Plate 11: (a) Rose-ringed Parakeet on Neem tree (b) White-breasted Kingfisher on Neem tree (c) Pair of Rose-ringed Parakeet on Neem tree

Table 11: Relative abundance of bird species on Neem tree at location II from April 2016 – March 2017

Sr. No.	Months → Birds ↓	April	May	June	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	March	Annual abundance
1	Asian Koel	-	2.91	-	-	-	-	-	-	-	-	-	-	0.32
2	Black Drongo	5.78	7.29	2.59	8.92	5.17	-	2.58	0.92	14.00	21.15	7.37	5.43	5.80
3	Brown Fish-Owl	-	-	-	-	-	-	-	-	-	-	1.63	-	0.16
4	Common Golden-backed Woodpecker	-	-	-	-	-	-	-	-	2.00	-	1.63	0.54	0.16
5	Common Hoopoe	-	-	-	-	-	-	-	-	-	-	-	1.08	1.16
6	Common Myna	29.47	28.46	38.96	41.07	50	49.48	43.96	62.96	68.00	26.92	17.21	27.71	37.31
7	Common Tailor-bird	10.00	10.21	3.89	8.92	1.72	1.03	8.62	-	-	15.38	18.03	12.5	8.06
8	Eurasian Collared-Dove	1.05	-	-	-	1.72	1.03	1.72	-	-	-	0.81	1.63	0.81
9	Greater Coucal	0.52	-	-	-	-	-	-	-	-	-	-	0.54	0.16
10	House Crow	1.57	2.91	-	-	-	-	-	-	-	-	-	-	0.56
11	House Sparrow	12.63	17.51	20.77	10.71	3.44	6.18	-	-	-	3.84	8.19	8.69	8.54
12	Indian Chat	-	-	-	-	-	-	2.58	1.85	-	-	1.63	0.54	0.64
13	Indian Grey Hornbill	-	-	-	-	-	-	-	0.92	-	-	5.73	1.08	0.81
14	Indian Treepie	-	-	-	-	-	2.06	2.58			3.84		3.80	1.13
15	Jungle Babbler	4.73	2.18	7.79	16.07	12.06	11.34	9.48	9.25	4.00		4.09	4.34	6.53
16	Little Brown Dove	5.26	3.64	5.19	5.35	6.89	4.12	7.75	7.40	-	5.76	6.55	2.71	5.32
17	Purple Sunbird	5.26	2.91	-	-	-	-	-	-	-	-	-	7.06	2.18
18	Red-vented Bulbul	6.84	4.37	1.29	-	5.17	9.27	6.03	0.92	4 .00	11.53	6.55	5.43	5.32
19	Rose-ringed Parakeet	15.26	16.78	19.48	8.92	1206	15.46	12.93	13.88	8 .00	3.84	10.65	11.95	13.30
20	Spotted Owlet	0.52	-	-	-	1.72		1.72		-	-	1.63	0.54	0.56
21	White-breasted Kingfisher	1.05	0.72	-	-	-	-	-	1.85	-	-	1.63	1.63	0.81
22	Yellow-legged Green-Pigeon	-	-	-	-	-	-	-	-	-	7.69	6.55	2.71	1.37
	Richness	14	12	8	7	10	9	11	9	6	9	16	19	
	Diversity	2.15	2.07	1.64	1.70	1.67	1.58	1.85	1.25	1.07	1.95	2.45	2.38	
	Evenness	0.81	0.83	0.78	0.87	0.72	0.72	0.77	0.57	0.60	0.89	0.88	0.81	

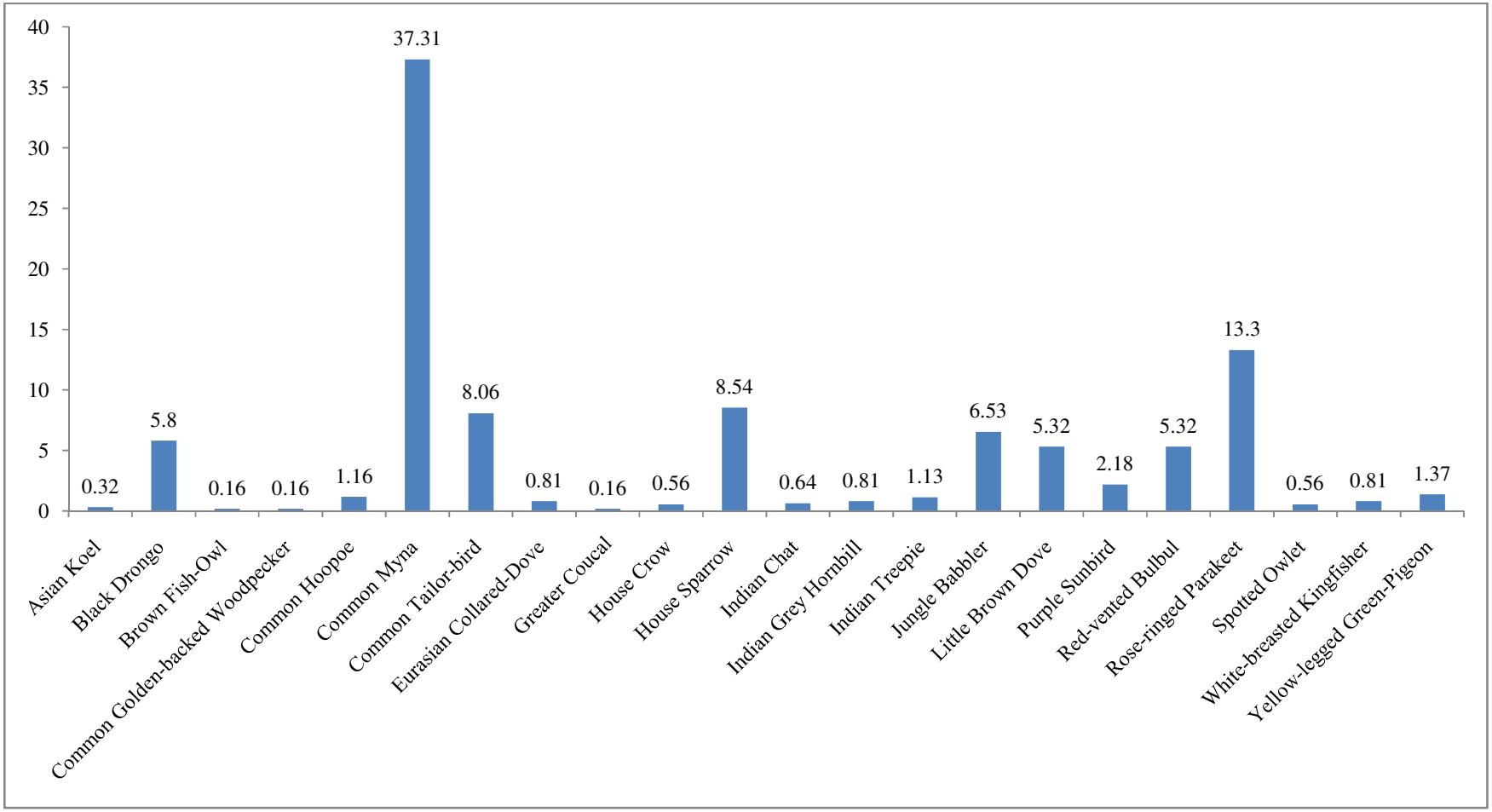

Fig.20: Annual abundance of bird species on Neem tree at location II

Feeding habits

At location I omnivorous bird species were the most dominant with annual abundance 50.11 followed by 27.98 of frugivorous species (Fig. 21). Abundance of carnivorous, granivorous and insectivorous birds was 0.20, 9.42 and 12.93 respectively. Similarly at location II omnivorous bird species were most dominant with annual abundance 58.83 (Fig. 22). Abundance of insectivorous and frugivorous birds was 17.67 and 16.85. Abundance 6.69 was of granivorous species. Carnivorous bird species (0.97) were least abundant.

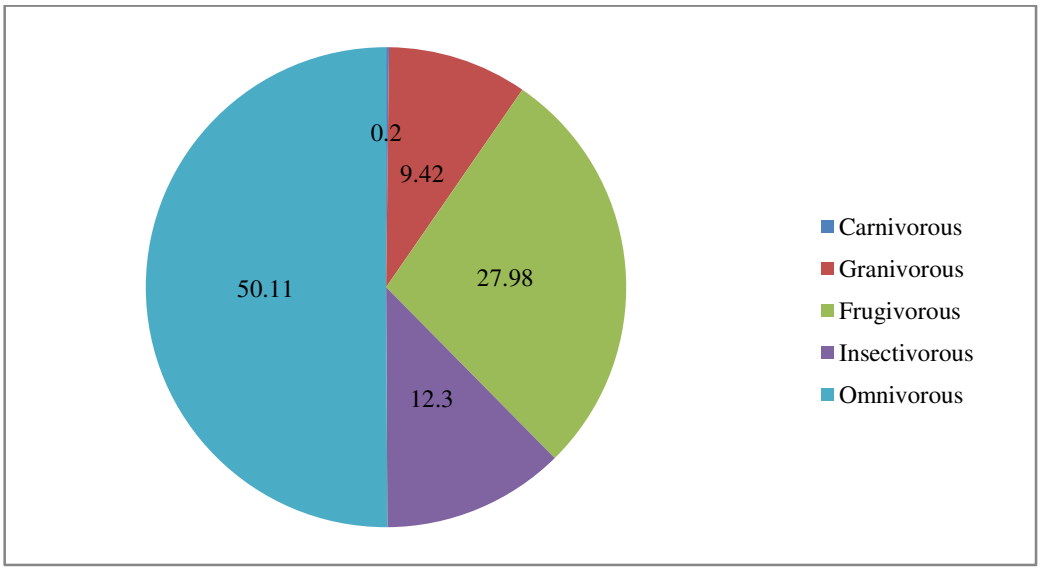

Fig.21: Distribution of bird species according to their feeding habits on Neem tree at location I

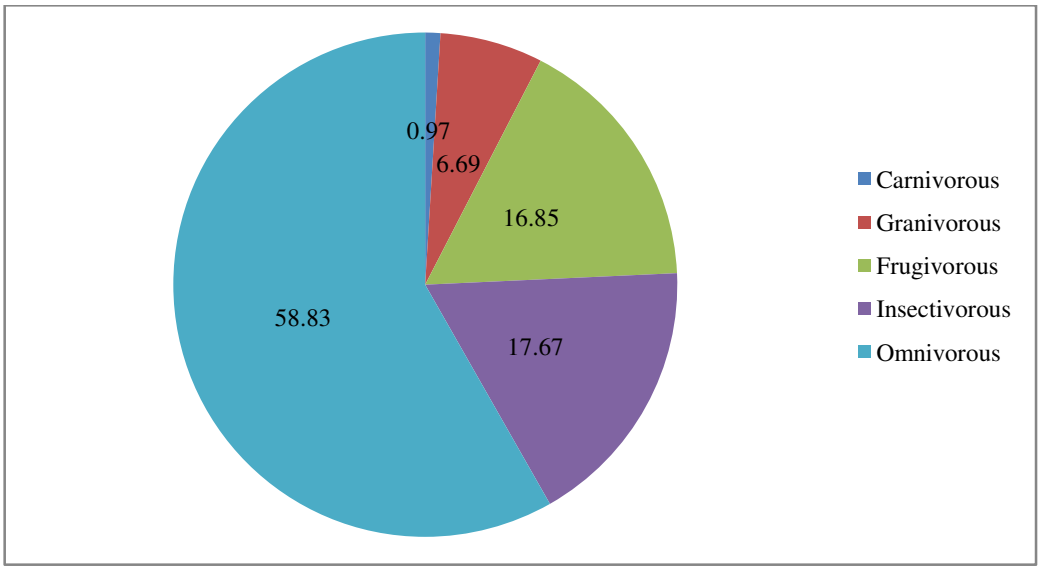

Fig.22: Distribution of bird species according to their feeding habits on Neem tree at location II

Orders

Bird species recorded on Neem tree at location I belonged to 8 orders (Fig.23). Bird species belonging to order Passeriformes were most dominant with annual abundance 58.93 followed by 23.93 of order Psittaciformes. Abundance of birds belonging to orders Columbiformes, Cuculiformes, Coraciformes and Upupiformes and Bucerotiformes was 12.09, 0.47, 2.54, 0.40 and 1.47 respectively. Birds belonging to order Piciformes were least abundant (0.2).

At location II birds recorded belonged to 9 orders. Abundance of birds of order Psseriformes was highest (76.47) (Fig.24). Annual abundance of other orders like Strigiformes, Columbiformes, Psittaciformes, Cuculiformes, Coraciformes, Upupiformes and Bucerotiformes was 0.72, 7.50, 13.30, 0.48, 0.81, 1.16 and 0.81 respectively. Birds of order Piciformes were least abundance (0.16).

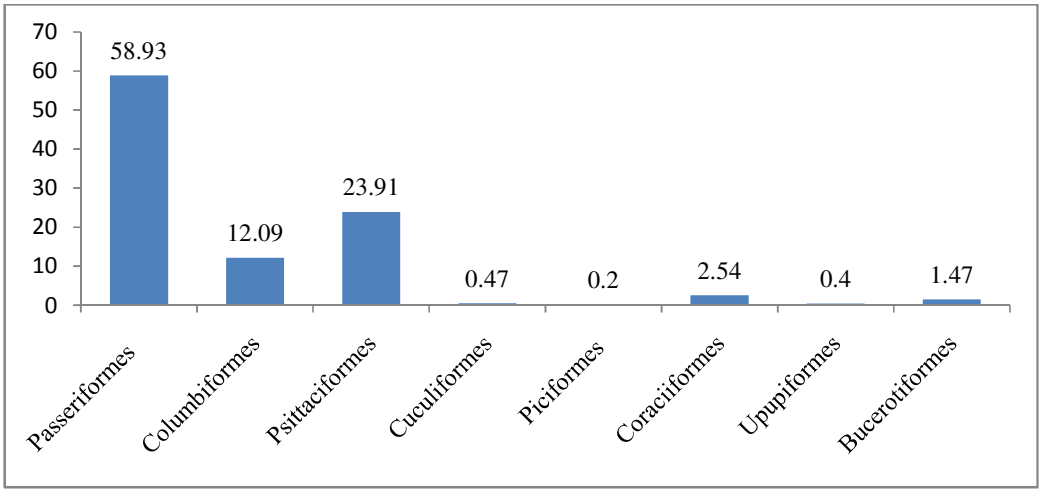

Fig.23: Distribution of bird species on Neem tree on the basis of their orders at location I

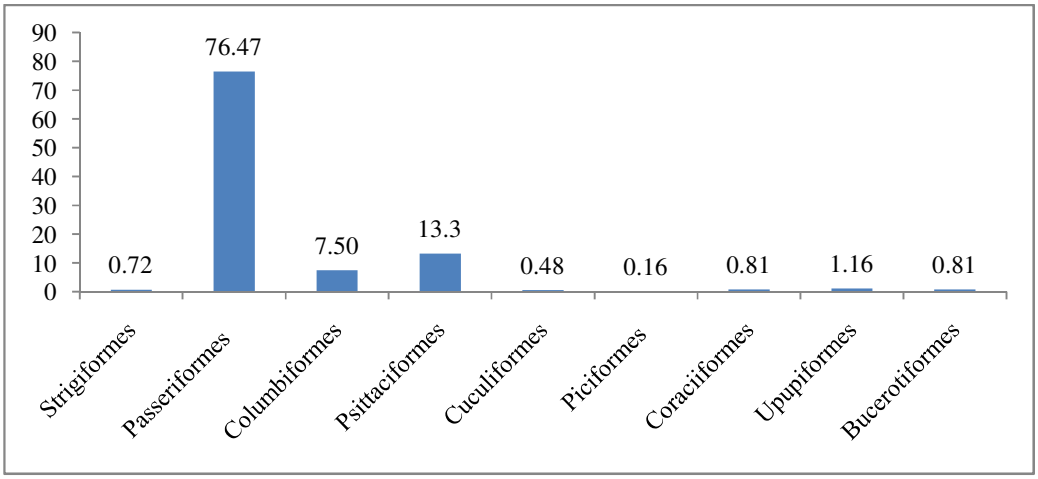

Fig.24: Distribution of bird species on Neem tree on the basis of their orders at location II

4.1.5 Pipal (*Ficus religiosa*)

Pipal belongs to family Moraceae. It is a large size tree with heart shaped leaves and spreading branches without aerial root. Figs turn dark purple on ripening and are consumed by flocks of birds. Ripening of fruits take place in month of March- April and also in October to November.

Location I

In total 31 species of birds were observed on Pipal tree during study (Table 12). Species richness was found highest that was 22 in month of April and February followed by 20 in month of October. Fruiting on tree occurs during February- April and October – November which attracts more bird species during these months. Highest species diversity 2.73 was recorded in month of March followed by 2.42 in month of April. Species evenness was recorded highest in month of December that was 0.89. Highest relative abundance 31.41 and 31.37 of Rose-ringed Parakeet was observed in month of December and January respectively. Second highest relative abundance was of House Crow with value of 28.16 in month of August followed by 26.63 and 26.43 of Common Myna in month of July and August respectively. Coppersmith Barbet, Indian Treepie and Blue Rock Pigeon shows lowest relative abundance with value of 0.36 in month of April. Common Myna was the first dominant bird species with 23.51 annual abundance followed by House Crow and Rose-ringed Parakeet with 19.51 and 17.97 annual abundance respectively. Other species with less annual abundance were Coppersmith Barbet (0.13), Eurasian Wryneck (0.04), Common Golden-backed Woodpecker (0.13), Eurasian Golden Oriole (0.04), Indian Cuckoo (0.125), Asian Pied Starling (0.13) and White-breasted Kingfisher (0.13) (Plate 12,13).

Location II

Total 25 species of birds were recorded on Pipal tree at village Machaki Mal Singh (Faridkot) during study period (Table 13). Maximum number of species were found in the month of March (18) followed by April (16) and May (16). Species richness was lowest (5) in the month of December. Species diversity was highest in the month of March (2.27) and April (2.28). It was lowest (1.51) in the month of August. Species evenness was highest in the month of September (0.88) and April (0.82). Relative abundance of Rose-ringed Parakeet was highest in the month of December (50.0) and January (40.57). Relative abundance of Common Myna was second highest in the month of August (40.24) and September (38.77). Ramachandra *et al* (2014) also reported that birds love to feed on figs and also help in seed dispersal. Common Myna was the most dominant species with 29.29 annual abundance followed by 26.30 annual abundance of Rose-ringed Parakeet. Asian Pied Starlinhg and Indian Shikra were least abundant bird species both having 0.08 annual abundance (Plate 12, 13).

Table 12: Annual abundance of bird species on Pipal tree at location II from April 2016 - March 2017

Sr. No	Months → / Birds ↓	April	May	June	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	March	Annual abundance
1.	Ashy Prinia	-	-	-	-	-	1.35	0.48	-	-	-	0.90	-	0.25
2.	Asian Koel	1.47	0.83	-	-	-	0.45	0.97	-	-	-	-	-	0.38
3.	Asian Pied Starling	0.73	-	-	-	-	-	-	-	-	-	-	-	0.13
4.	Bank Myna	0.94	-	-	-	-	0.45	1.95	-	-	-	-	-	0.50
5.	Black Drongo	2.20	1.66		1.08			0.97	0.58	-	-	1.36	3.21	1.13
6.	Black Kite	12.13	12.50	14.00	11.41	13.79	13.96	10.73	9.41	8.45	14.37	9.09	10.84	11.13
7.	Blue Rock Pigeon	0.36	0.83	-	-	-	1.45	0.48	1.17	-	-	2.72	1.20	0.71
8.	Brown-headed Barbet	-	-	-	-	-	-	0.48	1.76	-	-	1.81	-	0.33
9.	Common Golden-backed Woodpecker	0.73	-	-	-	-	0.45	-	-	-	-	-	-	0.13
10.	Common Myna	22.05	23.75	25.60	26.63	26.43	22.52	25.85	27.64	21.83	18.30	17.72	18.87	23.51
11.	Common Tailor-bird	-	-	-	-	0.57	0.90	-	0.58	-	-	0.90	1.20	0.42
12.	Coppersmith Barbet	0.36	-	-	-			0.97		-	-	-	-	0.13
13.	Eurasian Collared-Dove	1.83	3.33	1.44	-	0.57	3.15	3.90	1.17	-	-	0.90	2.40	1.75
14.	Eurasian Golden Oriole	0.73	-	-	-	-	-	-	-	-	-	-	-	0.08
15.	Eurasian Wryneck	-	-	-	-	-	-	-	-	-	-	-	0.40	0.04
16.	Green Bee-eater	4.04	-	-	-	-	-	-	-	-	-	1.81	3.81	0.96
17.	House Crow	15.44	20	26.57	22.28	28.16	20.72	19.02	18.23	19.71	19.60	16.81	15.66	19.51
18.	Indian Cuckoo	-	-	-	-	-	-	-	0.58	-	-	0.90	-	0.13
19.	Indian Grey Hornbill	4.41	2.08	0.96		0.57	-	1.46	-	-	-	3.63	4.41	1.75
20.	Indian Peafowl	-	-	1.93	1.08	-	-	0.48	-	-	-	0.45	-	0.33
21.	Indian Shikra	0.73	-	-	-	-	-	-	-	-	-	0.45	-	0.13

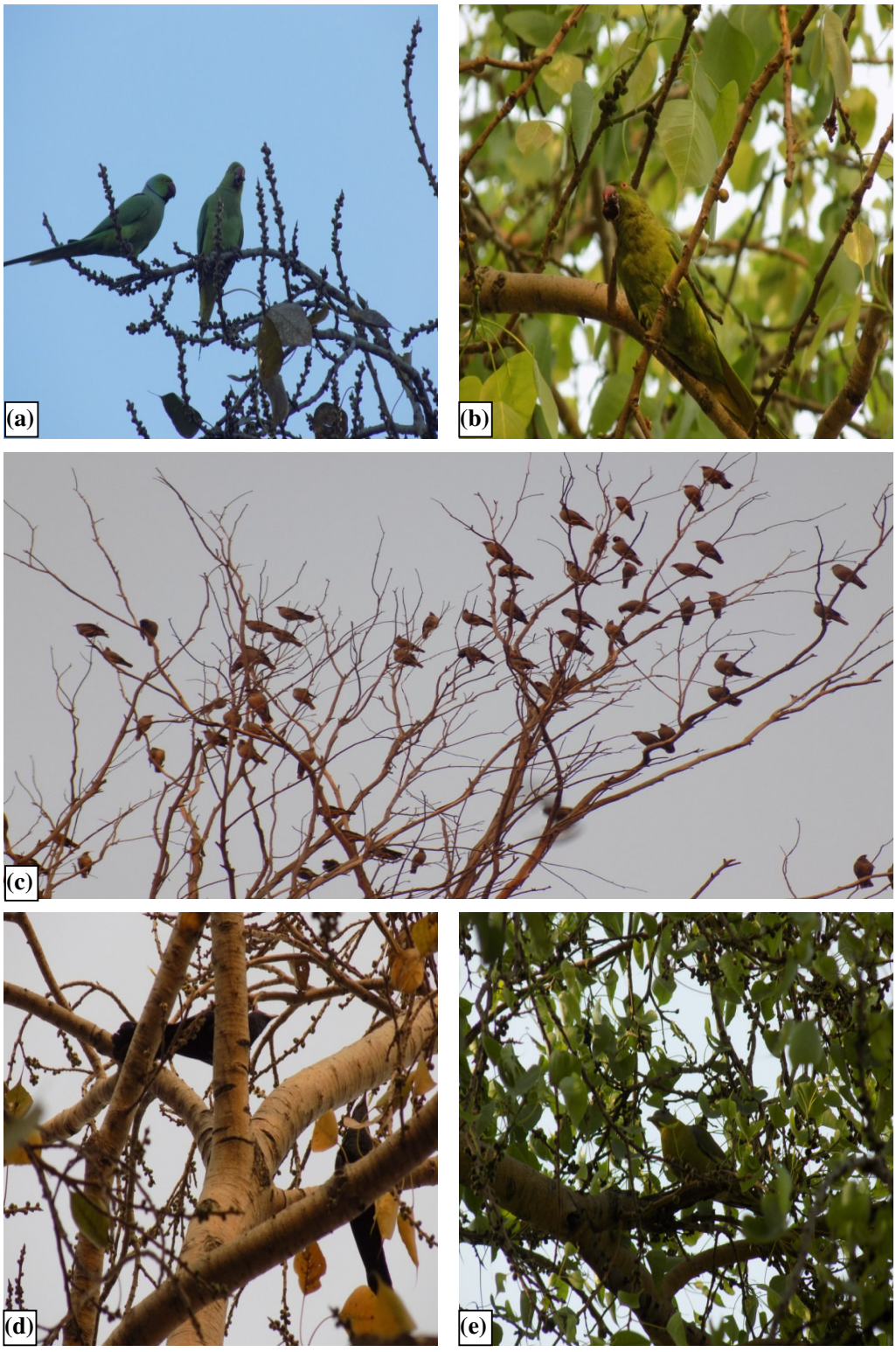

Plate 12: **(a) Pair of Rose-ringed Parakeet on Pipal tree (b) Rose-ringed Parakeet feeding on fruits of Pipal tree (c) Flock of Common Myna on Pipal tree (d) Asian Koel on Pipal tree (e) Yellow-legged Green-Pigeon Pipal tree**

22.	Indian Treepie	0.36	-	-	-	-	0.45	0.48	1.17	-	0.65	1.36	2.00	0.58
23.	Jungle Babbler	11.39	16.66	17.87	22.28	18.96	17.11	14.14	10.58	8.45	6.53	5.90	10.04	13.75
24.	Little Brown Dove	-	0.83	-	1.63	-	1.80	0.97	1.17	-	-	2.72	1.20	0.92
25.	Oriental Magpie-Robin	1.10	-	-	-	-	-	0.97	-	-	-	-	0.40	0.25
26.	Purple Sunbird	2.94	1.25	-	-	-	-	-	-	-	-	1.36	2.00	0.79
27.	Red-vented Bulbul	1.10	16.66	0.96	0.54		1.35	0.97	1.76		1.96	1.81	2.40	1.33
28.	Rose-ringed Parakeet	11.76	14.58	10.14	13.04	10.34	13.51	13.65	21.17	31.41	31.37	24.09	18.47	17.97
29.	Spotted Owlet	-	-	0.48	-	0.57	-	-	1.76	-	-	-	0.80	0.29
30.	White-breasted Kingfisher	-	-	-	-	-	0.45	-	-	-	-	0.90	-	0.13
31.	Yellow-legged Green-Pigeon	1.10	-	-	-	-	-	0.97	1.17	5.63	7.18	2.72	0.80	1.42
	Richness	22	13	10	9	9	16	20	16	6	8	22	19	
	Diversity	2.42	2.00	1.76	1.72	1.65	2.02	2.16	2.02	1.59	1.75	2.39	2.73	
	Evenness	0.78	0.78	0.76	0.78	0.75	0.73	0.72	0.72	0.89	0.79	0.77	0.80	

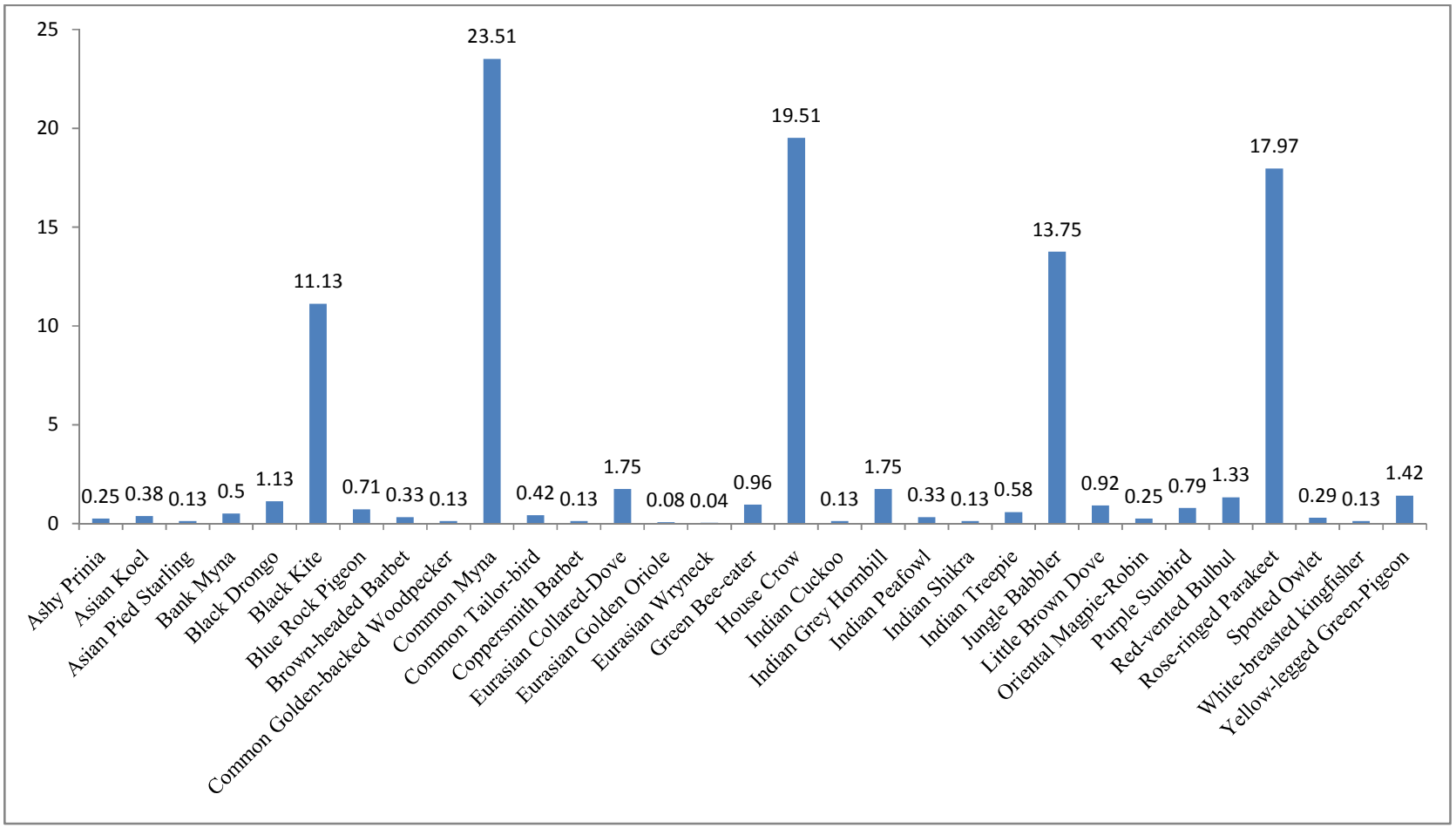

Fig 25: Annual abundance of bir d species on Pipal tree at location I

Plate 13: (a,b) House Crow on Pipal tree (c) Indian Peafowl on Pipal tree (d,e) Pair of Spotted owlet on Pipal tree

Table 13: Relative abundance of bird species on Pipal tree at location II from April 2016 - March 2017

Sr,. No.	Months → / Birds ↓	April	May	June	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	March	Annual abundance
1	Ashy Prinia	1.94	1.31	-	-	-	1.02	1.19	-	-	-	-	2.54	0.87
2	Asian Koel	7.79	9.86	6.55	3.47	-	-	-	-	2.00	-	1.70	5.73	4.02
3	Asian Pied Starling	-	-	-	-	-	-	1.19	-	-	-	-	-	0.08
4	Bank Myna	1.29	-	-	-	-	-	-	-	-	-	-	-	0.16
5	Black Drongo	2.59	3.94	6.55	2.60	7.31	-	1.19	2.50	-	-	1.70	2.54	2.83
6	Blue Rock Pigeon	0.64	-	-	1.73	-	-	1.19	-	-	-	1.70	-	0.47
7	Common Myna	20.12	26.31	30.32	36.52	40.24	38.77	34.52	22.50	24.00	28.98	22.22	22.92	29.29
8	Coppersmith Barbet	-	-	-	-	-	-	-	2.50	-	-	-	-	0.16
9	Eurasian Collared-Dove	0.64	2.63	2.45	5.21	2.43	1.02	2.38	5.00	-	2.89	3.41	1.91	2.52
10	Eurasian Golden Oriole	-	-	-	-	2.43	-	-	1.25	-	-	-	1.91	0.47
11	Golden-backed Woodpecker	-	0.65	-	-	-	-	-	-	-	-	1.70	-	0.24
12	Green Bee-eater	6.59	3.94	1.63	-	-	-	-	-	-	-	-	1.91	1.65
13	House Crow	-	-	-	-	-	-	-	-	-	-	-	1.27	0.16
14	Indian Chat	2.59	1.97	-	5.21	-	1.02	-	2.50	-	-	-	1.27	1.42
15	Indian Cuckoo	-	-	-	-	-		2.38		-	-	-	-	0.16
16	Indian Grey Hornbill	4.54	1.97		-	-	2.04	1.19	3.75	-	-	5.12	2.54	2.05
17	Indian Shikra	-	-	-	-	-	1.02	-	-	-	-	-	-	0.08
18	Indian Treepie	-	-	-	-	-	3.06	2.38	1.25	-	-	1.70	0.63	0.71
19	Jungle Babbler	14.28	17.76	27.04	25.21	25.60	24.48	21.42	16.25	10.00	8.69	10.25	12.73	18.11

20	Little Brown Dove	0.64	1.97	0.81	1.73	3.65	2.04	1.19	1.25	-	4.34	0.85	1.27	1.57
21	Purple Sunbird	-	1.31	-	-	-	-	-	-	-	-	-	1.91	0.39
22	Red-vented Bulbul	3.89	1.97	1.63	-	-	3.06	2.38	1.25	-	2.89	2.56	2.54	2.05
23	Rose-ringed Parakeet	23.37	21.71	22.95	17.39	18.29	19.38	27.38	32.50	50.00	40.57	33.33	26.75	26.30
24	White-breasted Kingfisher	3.89	1.31	-	0.86	-	3.06	-	2.50			2.56	2.54	1.65
25	Yellow-legged Green-Pigeon	5.19	1.31	-	-	-		-	5.00	14.00	11.59	11.11	7.00	4.17
	Richness	16	16	9	10	7	12	13	14	5	7	14	18	
	Diversity	2.28	2.14	1.67	1.72	1.51	1.69	1.72	2.00	1.27	1.52	2.02	2.27	
	Evenness	0.82	0.77	0.76	0.74	0.78	0.88	0.67	0.76	0.79	0.78	0.76	0.78	

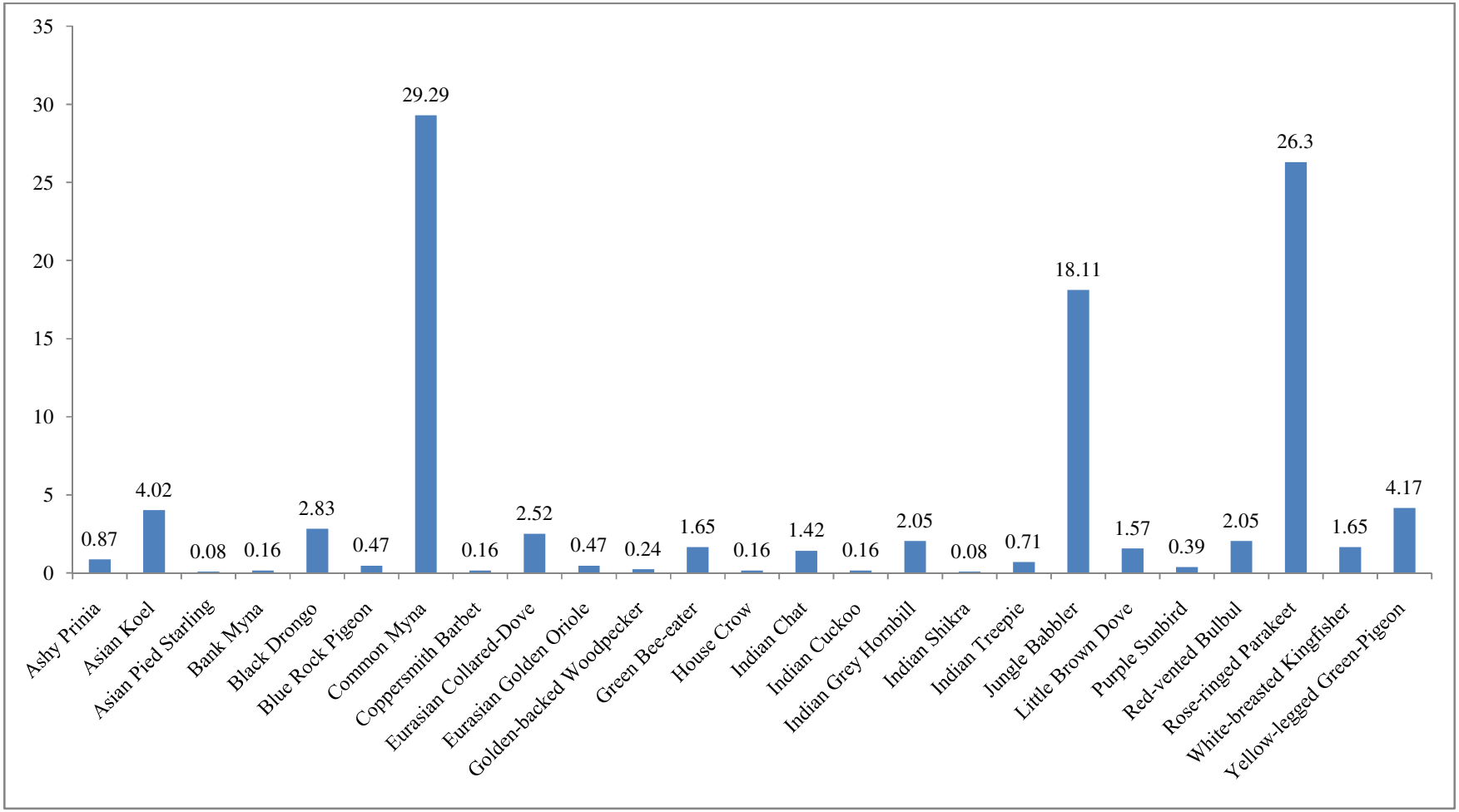

Fig. 26: Annual abundance of bird species recorded on Pipal tree at location II

Feeding habits

Omnivorous birds were most dominant at location I with abundance 61.02 followed by 20.13 abundance of frugivorous birds (Fig.27). Least abundance 3.38 was of granivorous birds. At location II highest abundance (55.76) was of omnivorous birds followed 31.02 of frugivore birds (Fig.28). Least abundance (4.56) was of granivorous birds.

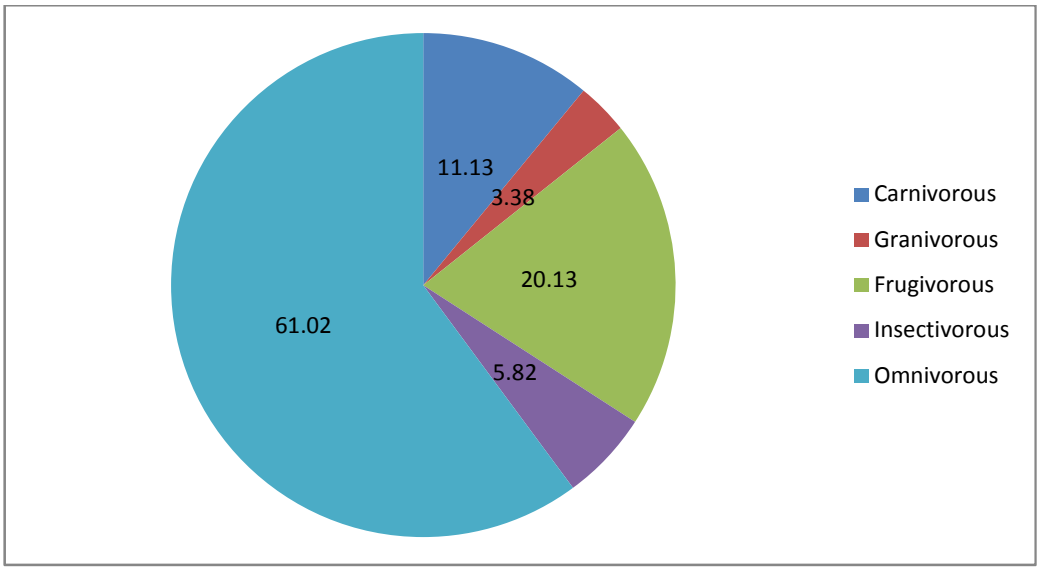

Fig. 27: Distribution of bird species according to their feeding habits on Pipal tree at location I

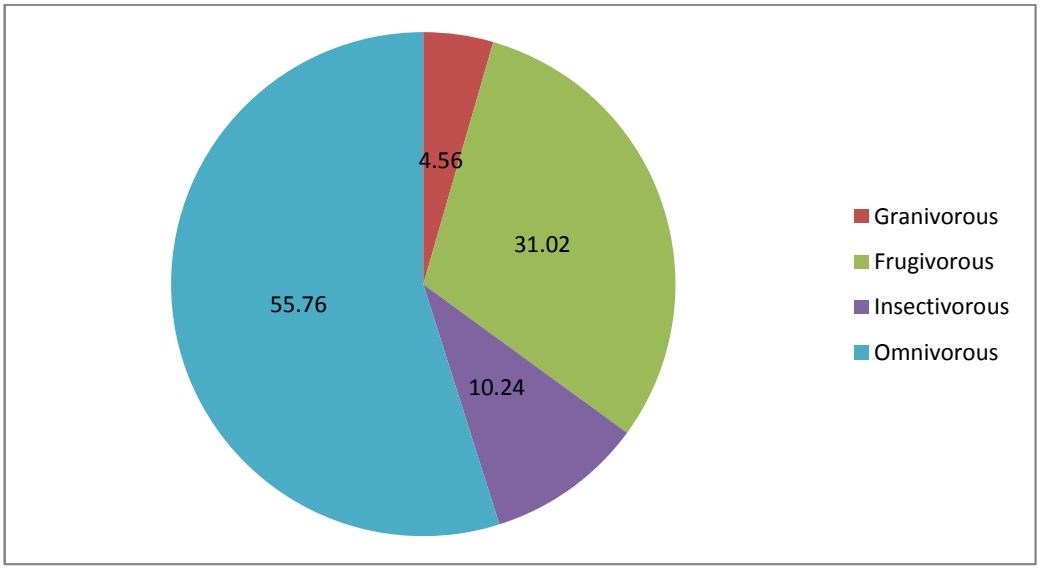

Fig.28: Distribution of bird species according to their feeding habits on Pipal tree at location II

Orders

At location I highest abundance (62.23) was of birds belonging to order Passeriformes followed by abundance 17.97 of order Psittaciformes, least abundance (0.13) was of order Columbiformes and Accipitriformes (Fig. 29). At location II birds belonging to order Passeriformes were most dominant with abundance 56.54 followed by 26.30 of order Psittaciformes (Fig.30). Least abundance (0.08) was of order Accipitriformes.

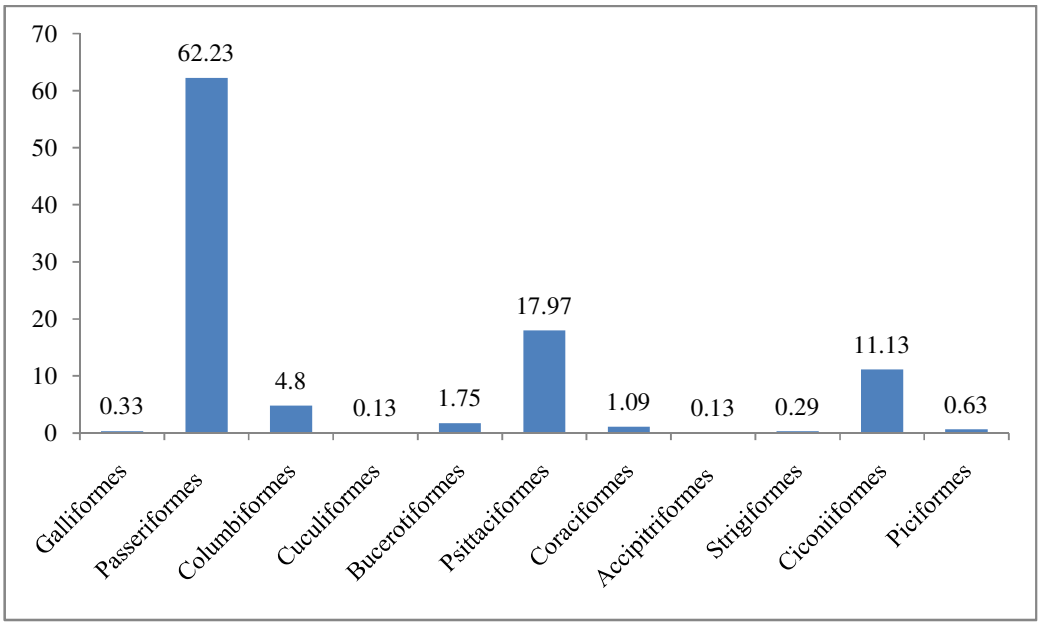

Fig.29: Distribution of bird species on Pipal tree on basis of their orders at location I

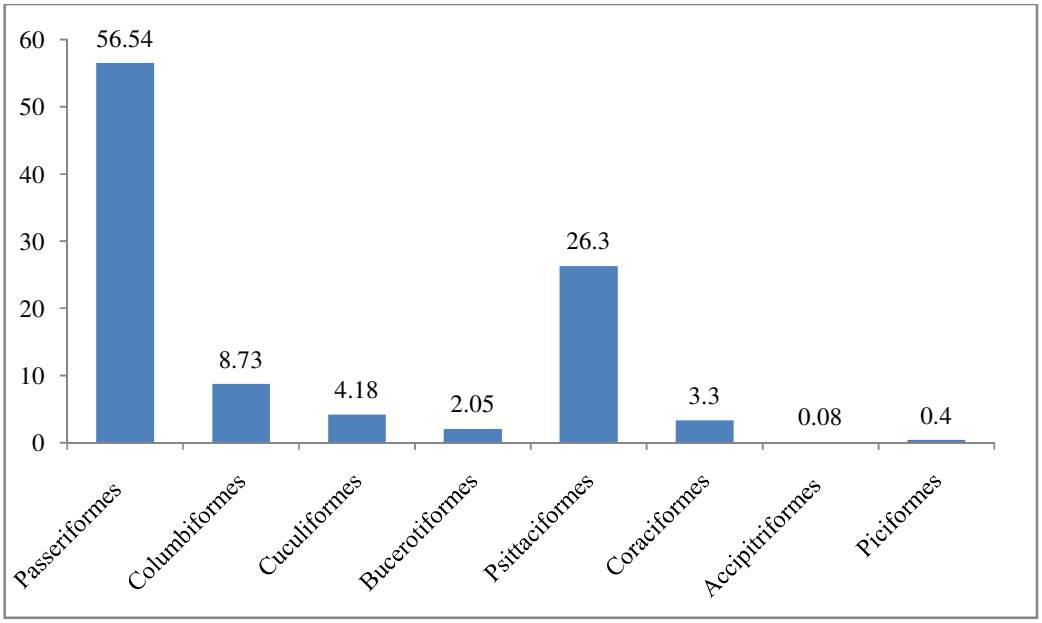

Fig.30: Distribution of bird species of on Pipal tree on basis of their orders at location II

4.1.6 Sheesham (*Dalbergia sissoo*)

It is fairly large deciduous tree with dark grey, rough and furrowed bark. It is fast growing tree adaptable and able to stand various temperatures. In the month of January-February tree is leafless and new foliage start appearing the month of March, flowering takes place in the month from March-April. Fruit ripens in the month of October and remain hanging on the trees for several months. Fruits are thin strap-shaped pods with kidney shaped light brown seeds.

Location I

Total 12 species of birds were recorded on Sheesham tree at location I (Table 14). Species richness was maximum in the month of March (12) and it was 11 in the months February, April and October. Species richness was almost same during all the three stages i.e new foliage, flowering and fruiting stages. Marwaha (2015) also stated that Sheesham tree supports bird diversity. Relative abundance of Common Myna (57.77) and (57.47) was highest in the month of September and July respectively. Least relative abundance of Little Brown Dove (0.56) was found in the month of February followed by 0.60 of Bank Myna in the month of October. Species diversity was highest in the month of March (1.93) followed by February (1.90) and April (1.84). It was lowest 0.83 in the month of December. Species evenness was highest in month of February (0.79). It was recorded to be 0.78 in March and 0.77 in months May and August. It was found to be lowest 0.26 in the month of December. Annual abundance of Common Myna (39.52) was recorded to be highest. Second highest annual abundance (28.31) was of Rose-ringed Parakeet. Lowest annual abundance (0.38) was recorded of Spotted Owlet.

Location II

Total 10 species of birds were recorded at location II (Table 15). Species richness was recorded to be highest (10) in the month of April which was a flowering period. It was 9 in the months September, October, January, February and March. Lowest species richness 5 was recorded in the month of December. Highest relative abundance 64.10 and 60.68 was of Common Myna in the month of December and October respectively. Lowest relative abundance 0.60 was of both Black Drongo and Yellow-legged Green-Pigeon in the month of April, followed by 0.64 of Black Drongo in the month of May. Species diversity was recorded to be highest (1.72) in the month of February and 1.61 was second highest in the month of March. Lowest species diversity 1.00 was found in the month of December. Species evenness was highest 0.78 in the month of February and it was lowest (0.62) in the months November and December. Annual abundance of Common Myna (42.76) was the highest followed by 28.43 of Rose-ringed Parakeet. Lowest Annual abundance 0.58 was of Spotted Owlet.

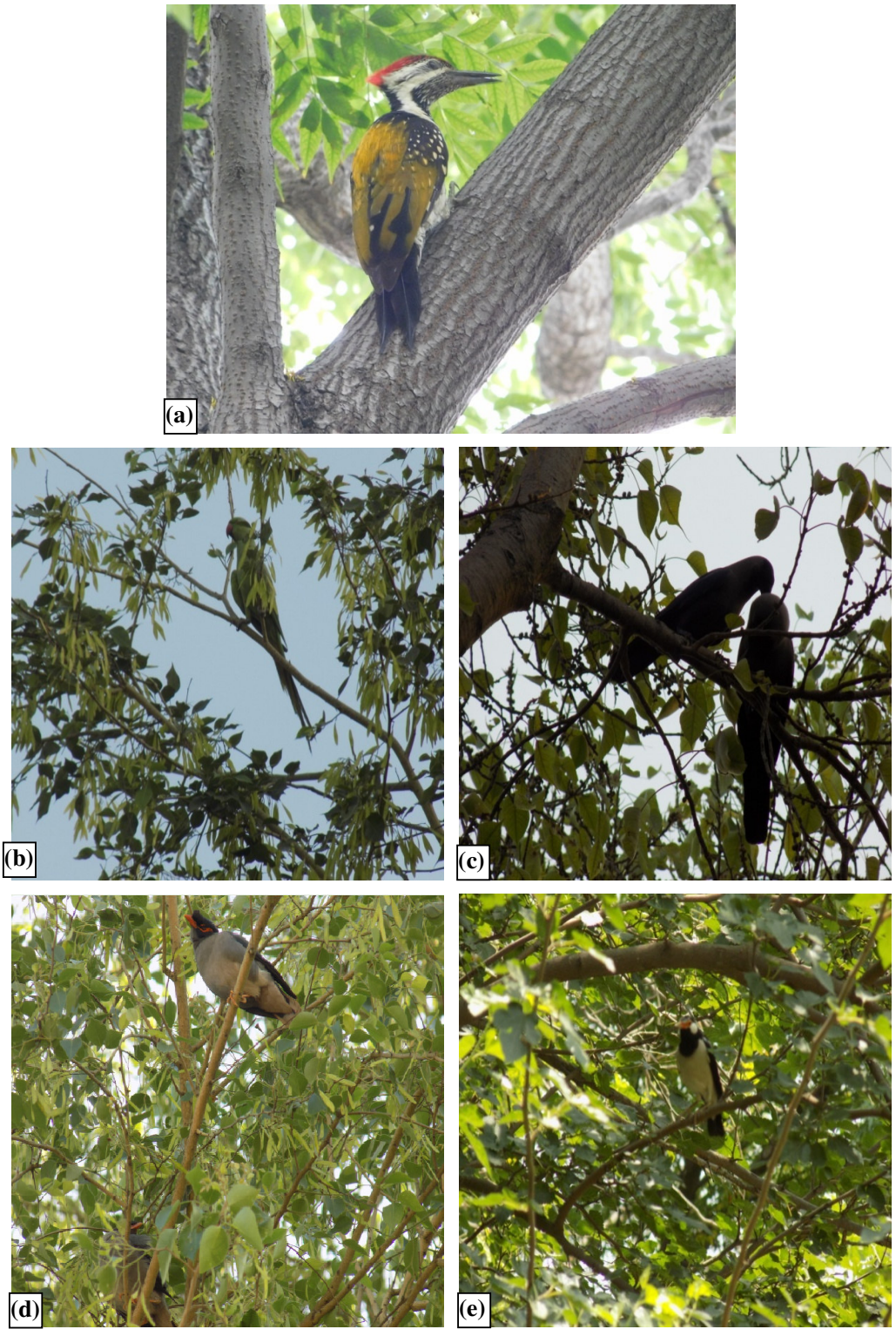

Plate 14: **(a) Common Golden-backed Woodpecker on Neem tree (b) Rose-ringed Parakeet on Sheesham tree (c) House Crow on Pipal tree (d) Bank Myna on Sheesham tree (e) Asian Pied Starling on Mulberry**

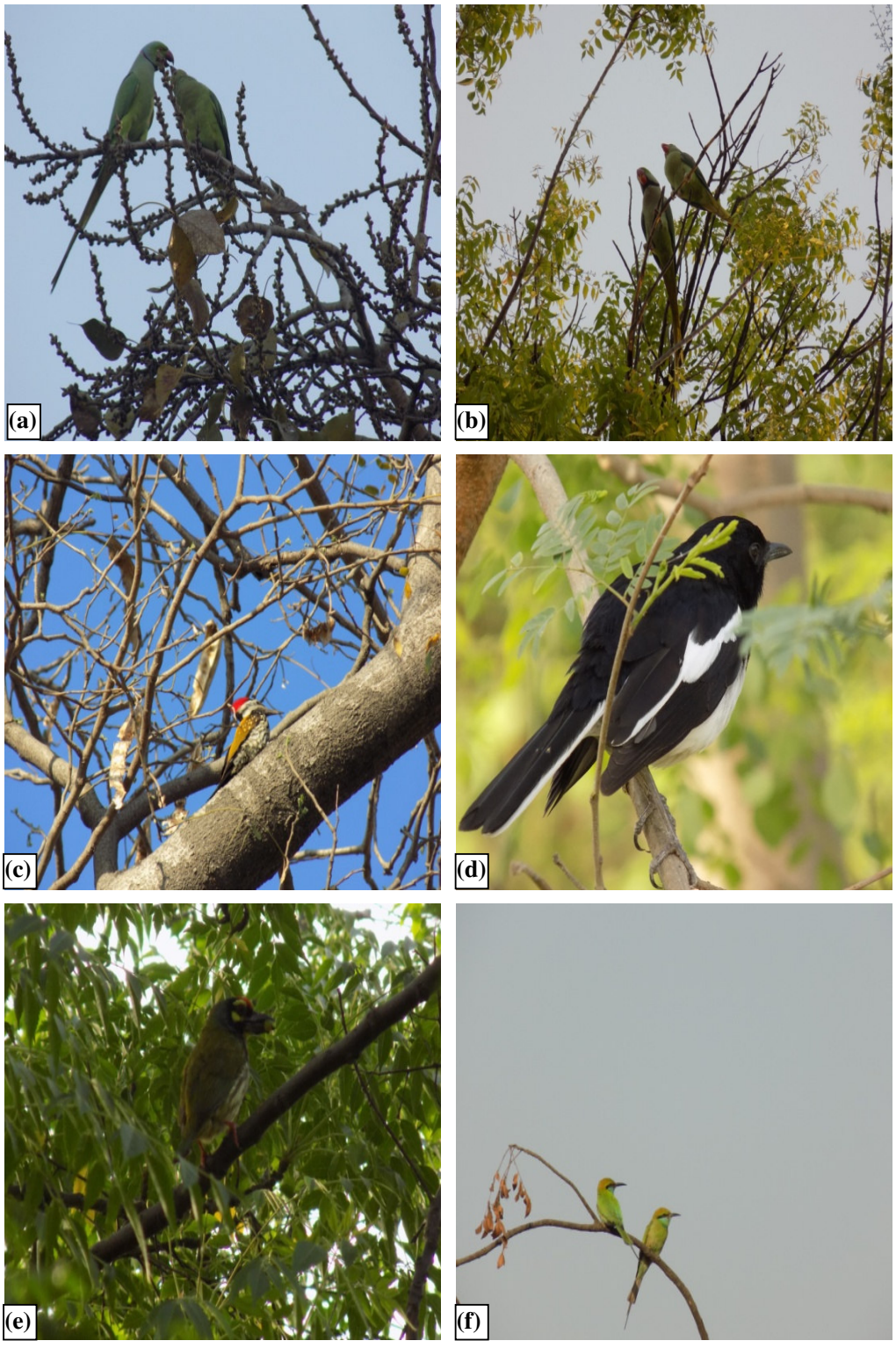

Plate 15: (a,b) Pair of Rose-ringed Parakeet (c) Common Golden-backed Woodpecker (d) Oriental Magpie-Robin (e) Coppersmith Barbet (f) Small Bee-eater

Table 14: Relative abundance of bird species on Sheesham tree at location 1 from April 2016- March 2017

Sr.No	Months → Birds ↓	April	May	June	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	March	Annual abundance
1	Bank Myna	-	-	-	-	-	-	0.60	-	-	-	5.05	2.51	0.87
2	Black Drongo	3.98	7.42	0.89	1.01	3.10	2.96	3.65	1.73	-	-	1.68	2.09	2.87
3	Black Kite	8.36	6.55	6.25	-	-	-	-	-	-	4.00	5.05	5.85	3.84
4	Common Myna	35.45	41.48	40.17	57.57	47.28	57.77	50.60	44.34	46.47	18.40	22.75	27.19	39.52
5	Eurasian Collared-Dove	1.99	1.74	2.67	2.02	2.32	2.96	1.82	3.47	-	1.60	1.12	0.83	1.84
6	House Crow	8.76	7.86	0.89	3.03	11.62	7.40	4.26	2.60	-	4.00	10.11	15.89	7.42
7	Jungle Babbler	10.35	10.04	20.53	7.07	10.07	2.22	4.87	4.34	49.29	4.80	6.17	6.61	7.20
8	Little Brown Dove	0.39	2.18	-	3.03	-	-	1.82	0.86	-	-	0.56	0.41	0.92
9	Red-vented Bulbul	3.98	3.05	0.89	3.03	4.65	4.44	3.04	6.08	-	2.40	2.24	5.02	3.47
10	Rose -ringed Parakeet	23.50	18.77	25.89	23.23	20.93	22.22	25.60	36.52	4.22	56.00	32.5	27.17	28.32
11	Spotted Owlet	0.79	-	-	-	-	-	1.82	-	-	-	-	1.25	0.38
12	Yellow-legged Green-Pigeon	2.39	0.87	1.79	-	-	-	1.82	-	-	8.80	12.92	5.02	3.36
	Richness	11	10	9	8	7	7	11	8	3	8	11	12	
	Diversity	1.84	1.78	1.50	1.28	1.50	1.27	1.52	1.35	0.83	1.40	1.90	1.93	
	Evenness	0.77	0.77	0.68	0.61	0.77	0.65	0.63	0.65	0.26	0.67	0.79	0.78	

Table 15: Relative abundance of bird species on Sheesham tree at location II from April 2016 – March 2017

Sr.No	Months → Birds ↓	April	May	June	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	March	Annual abundance
1	Bank Myna	3.65	-	-	-	-	-	3.41	-	-	-	-	1.61	1.02
2	Black Drongo	0.60	0.64	-	4.10	3.77	6.66	4.27	2.66	2.56	2.08	6.53	2.68	3.07
3	Common Myna	37.80	48.05	55.43	47.94	43.39	51.67	60.68	58.66	64.10	18.75	24.18	32.25	42.76
4	Eurasian Collared-Dove	4.87	3.89	2.17	2.73	2.83	4.16	2.56	5.33	2.56	5.20	3.92	2.15	3.58
5	Jungle Babbler	12.19	12.98	15.21	10.94	16.03	7.50	5.98	10.66	-	2.08	6.53	11.29	9.94
6	Little Brown Dove	2.43	3.89	-	5.47	2.83	1.66	2.56	-	-	1.04	1.30	1.07	1.97
7	Red-vented Bulbul	3.65	3.24	2.17	1.36	2.83	4.16	5.12	4.00	-	3.12	5.47	5.91	3.80
8	Rose-ringed Parakeet	32.31	22.72	23.91	27.39	28.30	17.5	13.67	17.33	23.07	56.25	37.25	36.55	28.44
9	Spotted Owlet	1.82	-	-	-	-	1.66	-	-	-	1.04	1.30	-	0.58
10	Yellow-legged Green-Pigeon	0.60	4.54	1.08	-	-	5.00	1.70	1.33	7.69	10.41	14.37	6.45	4.82
	Richness	10	8	6	7	7	9	9	7	5	9	9	9	
	Diversity	1.60	1.49	1.17	1.39	1.43	1.57	1.40	1.29	1.00	1.39	1.72	1.61	
	Evenness	0.69	0.71	0.65	0.71	0.73	0.71	0.63	0.62	0.62	0.63	0.78	0.73	

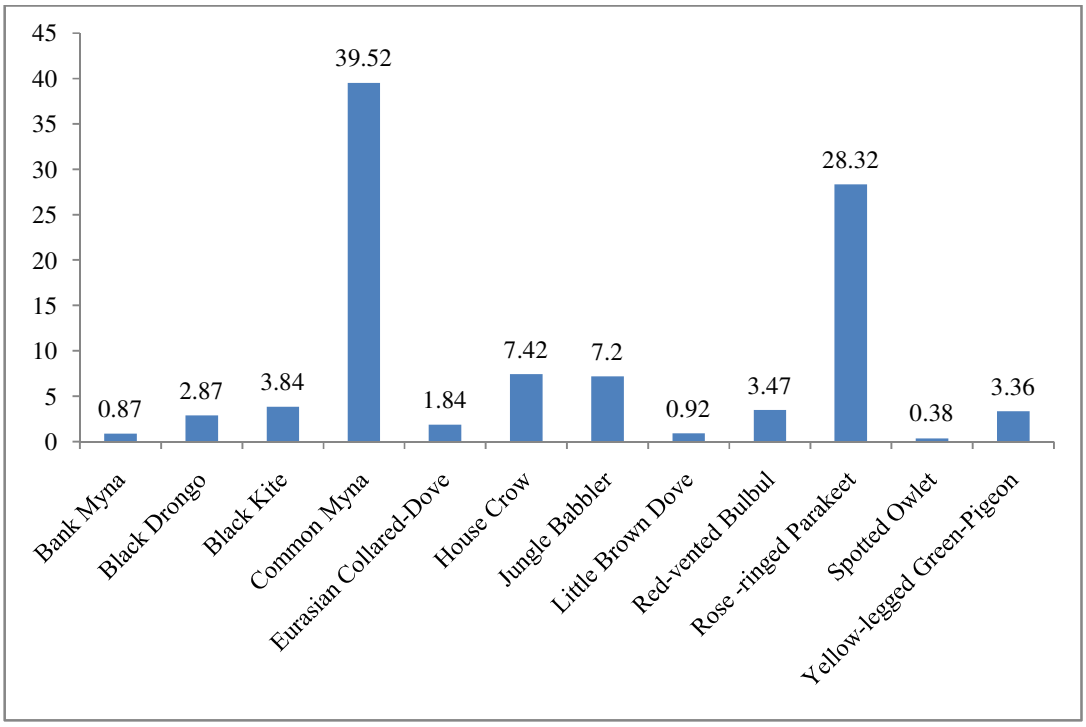

Fig. 31: Relative abundance of bird species on Sheesahm tree at location I

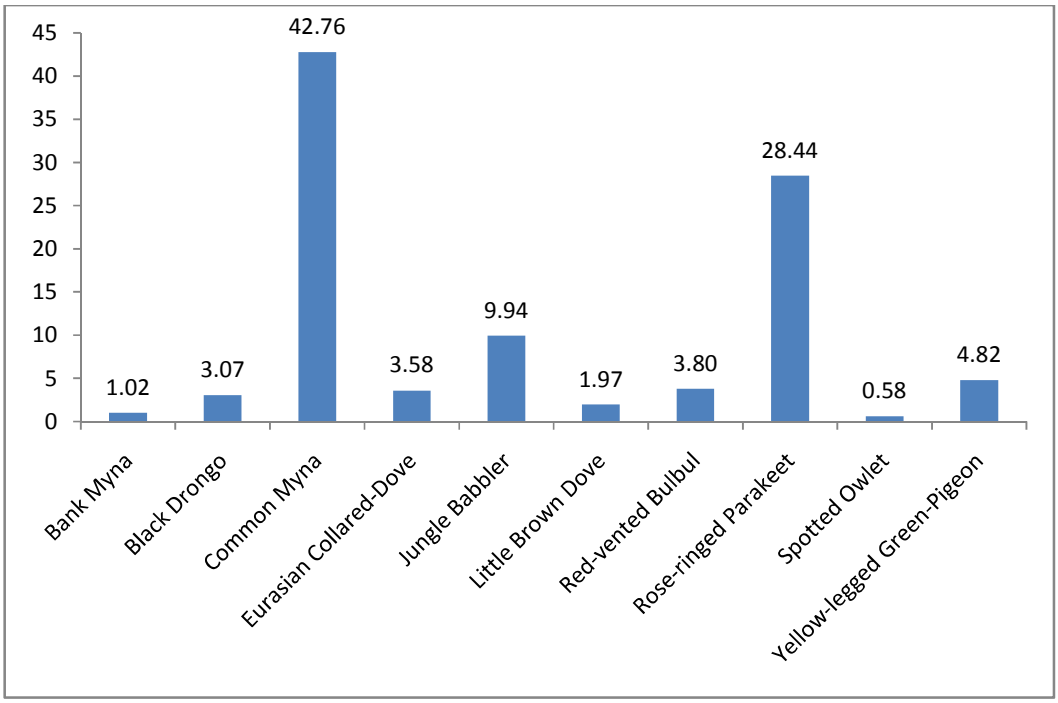

Fig. 32: Relative abundance of bird species on Sheesahm tree at location II

Feeding habits

Among the bird species found on Sheesham tree at location I, omnivorous bird species were found to be most dominant with annual abundance 57.61 followed by 31.68 of frugivorous species (Fig.33). Abundance of insectivorous and carnivorous bird species was 4.12 and 3.84 respectively. Least abundance 2.76 was of granivorous species. At location II, annual abundance of omnivorous birds was found to be highest (56.5) (Fig 34). Annual abundance of frugivorous and granivorous species was found 33.26 and 5.55 respectively. Insectivorous species with abundance 4.67 was recorded to be least dominant.

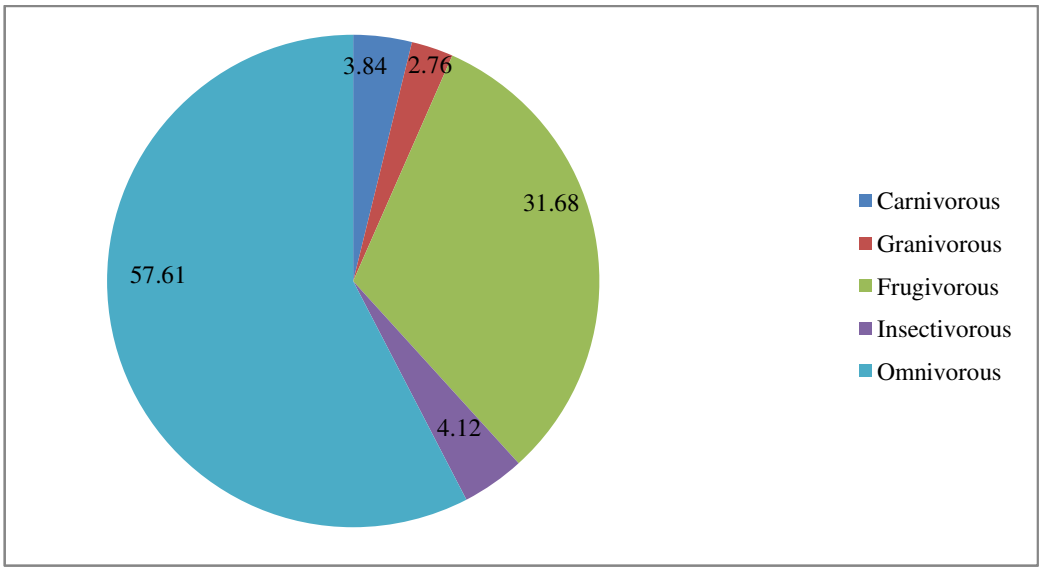

Fig.33: Distribution of bird species according to their feeding habits on Sheesham tree at location I

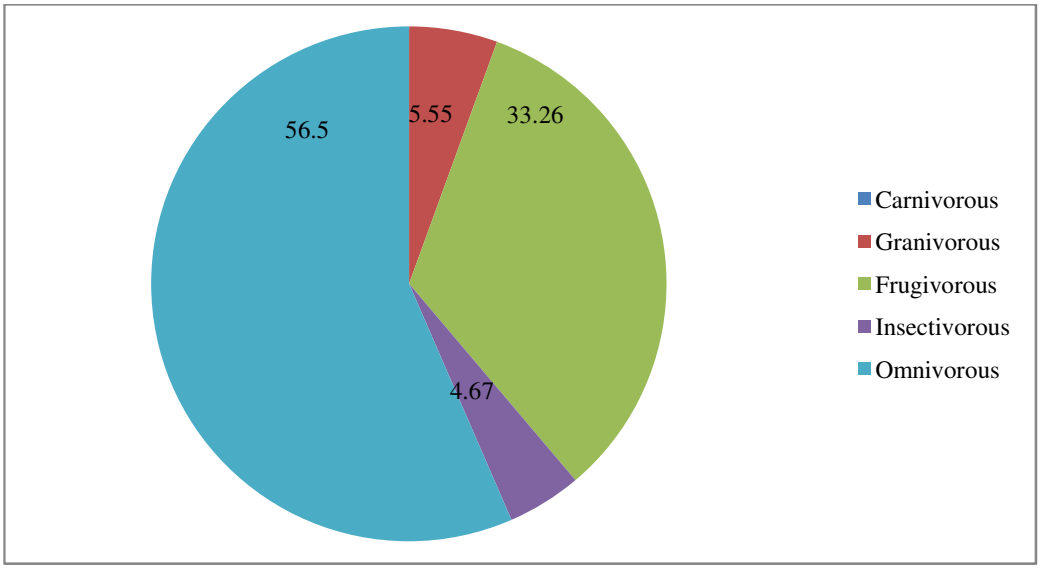

Fig.34: Distribution of bird species according to their feeding habits on Sheesham tree at location II

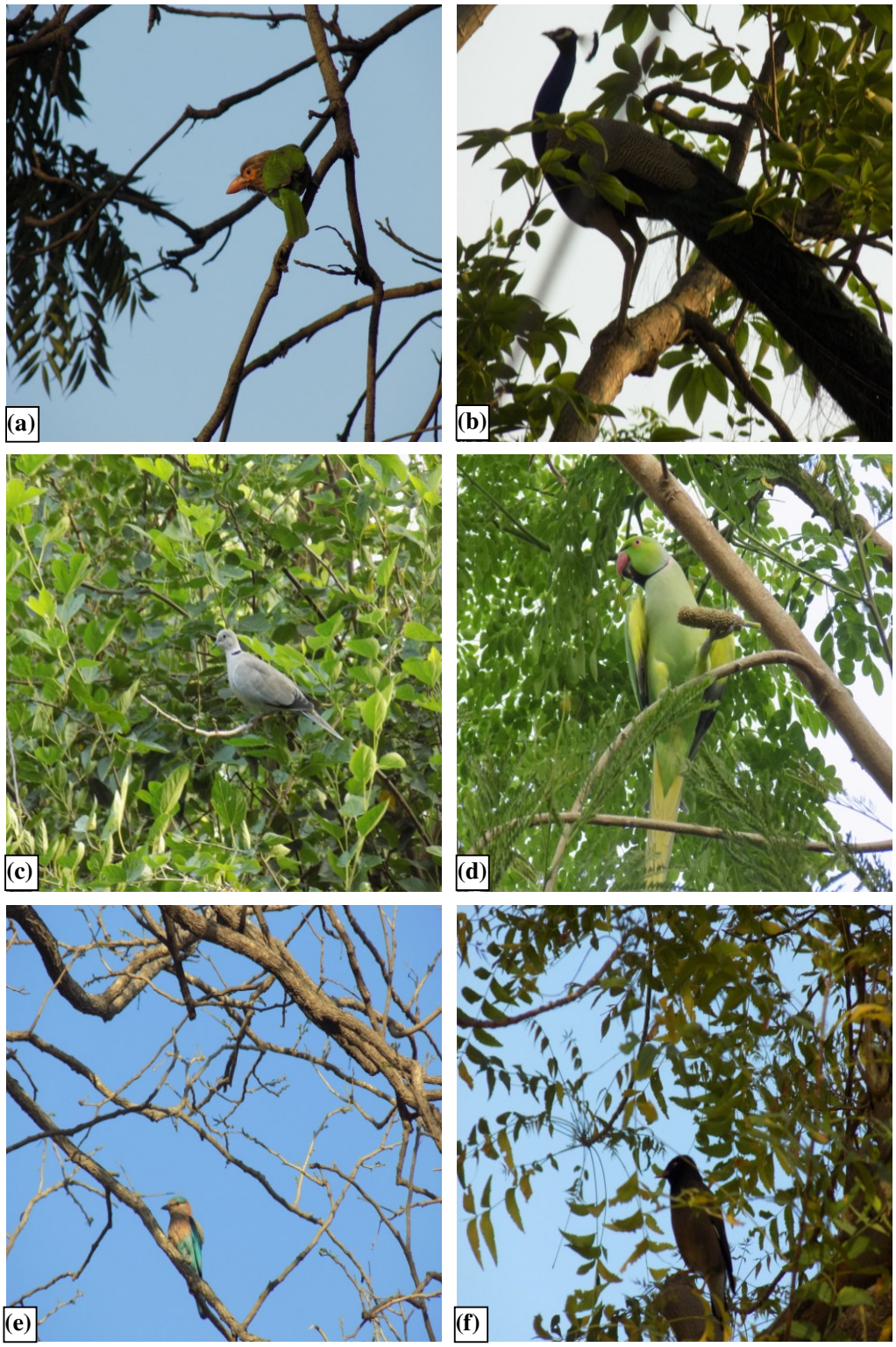

Plate 16: (a) Brown-headed Barbet (b) Indian Peafowl (c) Eurasian Collard-Dove (d) Rose-ringed Parakeet (e) Indian Roller (f) Common Myna

Orders

Bird species recorded on Sheesham tree at location I belonged to 5 orders (Fig. 35). Birds of order Psseriformes were most dominant with abundance 61.35 followed by 28.32 of Psittaciformes. Abundance of order Ciconiformes, Columbiformes and Strigiformes was 3.84, 6.12 and 0.38 respectively. At location II birds observed on Sheesham tree belonged to 4 orders (Fig. 36). Birds belonging to order Passeriformes were most dominant with abundance 60.59 followed by 28.44 of order Pssitaciformes. Abundance of order columbiformes and was 10.37 and least was of order Strigiformes with annual abundance 0.58.

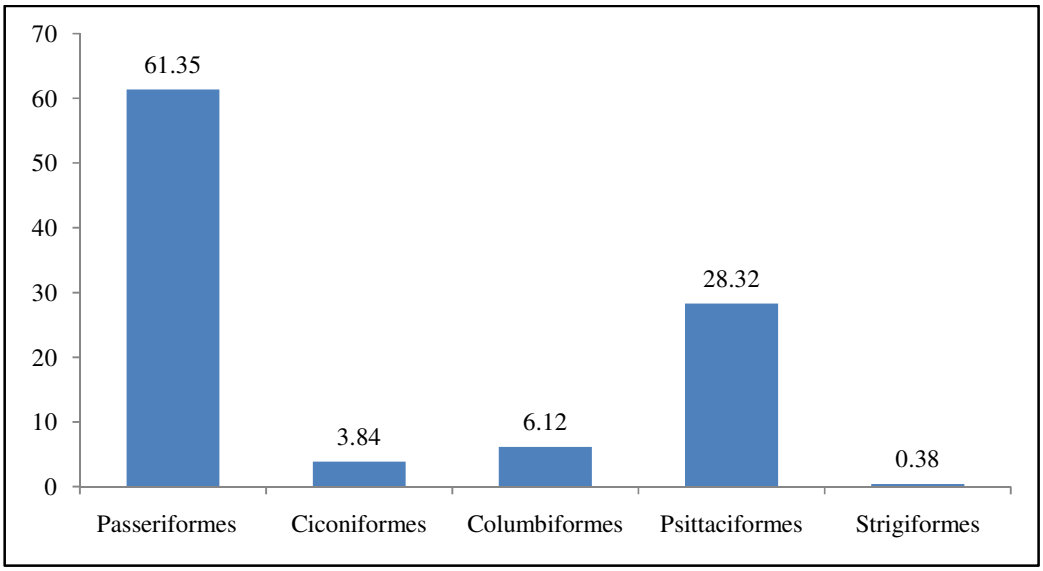

Fig.35: Distribution of bird species on Sheesham tree on the basis of orders oat location I

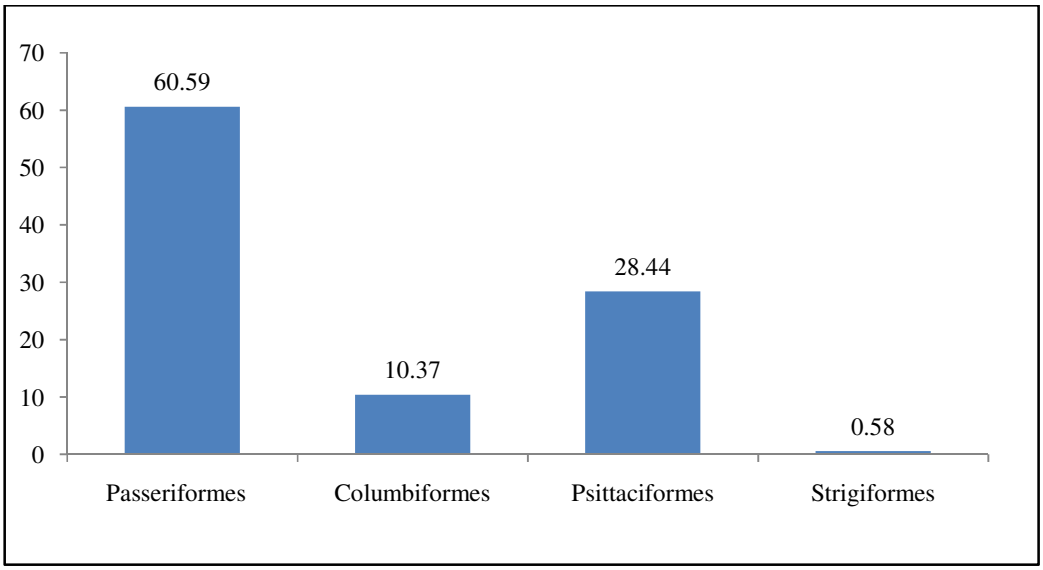

Fig.36: Distribution of bird species on Sheesham tree on the basis of orders at location II

Table 16: Comparative statistical analysis bird species among tree species of location I and II

Study areas	$\chi 2$	p
Location I	14.16	0.015
Location II	9.08	0.106

Statistical method of Kruskal-Wallis test was carried out to find the difference of bird species among all the selected tree species at location I and location II. Significant difference was observed among tree species of location I ($p < 0.05$) while no significant difference was observed among tree species of location II (Table 16). At location I all the trees were present at different sites and surrounding vegetation was also different at each area which may be the reason of significant difference at location I whereas at location all six trees were present at same site and surrounding vegetation was same for all the trees.

Table 17: Tree wise Comparative statistical analysis of abundance among both the locations

Tree species	Z
Banyan	1.52
Jamun	0.00
Mulberry	0.86
Neem	3.47*
Pipal	1.26
Sheesham	0.57

Statistical method Mann-Witney U test was carried out to find the difference of bird diversity on same tree species among both the locations. Significant difference was found only in case of Neem tree (Table 17). The reason of significant difference in case of Neem tree may be due to difference in crown size of trees at both locations. Crown size of trees at location II was large as compared to trees at location I.

4.2 The nesting behaviour of different bird species on indigenous trees.

Nesting of seven bird species was observed during study period. Total 14 nests were recorded on the trees selected for study. Out of which 12 were found at location I and only 2 were found at location II (Table 18). Three nests were found on Banyan tree, 2 on Jamun tree, 2 on Mulberry tree, 2 on Neem, 4 on Pipal tree and 1 on Sheesham tree. Nests of House Crow, Black Kite, Oriental Magpie-Robin, Asian Pied Starling and of Spotted Owlet was recorded at location I and of Little Brown Dove and Cattle Egret was found at location II.

Nesting of all these species was observed from April to September.

Table 18: Nests found on the selected trees

Tree	**No. of nest**	**Bird species** (n)		**Location**
Banyan	3	Black Kite	(1)	I
		House Crow	(1)	I
		Spotted Owlet	(1)	I
Jamun	2	Cattle Egret	(1)	II
		House Crow	(1)	I
Mulberry	2	Oriental Magpie-Robin	(1)	I
		Asian Pied Starling	(1)	I
Neem	2	House Crow	(1)	I
		Little Brown Dove	(1)	II
Pipal	4	Black Kite	(1)	I
		House Crow	(3)	I
Sheesham	1	Black Kite	(1)	I

4.2.1 Nesting of Black Kite

Three nests of Black Kite were recorded at location I on Banyan, Pipal and Sheesham in the month of April (Table 19).

On Banyan

Fully constructed nest of Black Kite was sighted on Banyan tree during second week of April during incubation period. Height of tree was recorded 21 m. Nest was situated at height of 12 m from ground. Nest was a rough platform of dry twigs, rags and polythenes situated in the forked branches of tree. Due to greater height of nest exact readings of number of eggs was not possible. Number of successfully raised chicks was assumed as clutch size. So, Clutch size observed was 2. Fledging was seen 45 days after hatching. Breeding characteristics of Black Kite were similar to earlier findings of Boumaaza *et al* (2016). Nest was vacated in the first week of June (Plate 17).

On Pipal

Fully constructed nest of Black Kite was noticed on Pipal tree at the site of Agronomy farm in the second week of April 2016 during its incubation period. Mayberg (1971) also reported a highly variable incubation period lasting from 25 to 38 days. Nest was situated at a height of 16m from ground and height of tree was measured 20 m from ground. One of the parents was observed sitting in the nest for incubation and other use to remain near the nest. Chicks were raised in the nest for 46-48 days. Nest was vacated in the last week of May (Plate 17).

Table 19: Nesting of Black Kite

Sr.No.	Tree	Site	Tree height (m)	Nest height (m)	Nest sighted	Material used	Clutch size	Fledging (Days after hatching)	Nest vacated
1.	Banyan	Tube well no 1	21	12	First week of April (during Incubation)	Rough platform of twigs, rags and polythenes	2	45 days	First week of June
2.	Pipal	Agronomy farm	20	16	Second week of April (during Incubation)	Rough platform of twigs and rags	2	46- 48 days	Last week of May
3.	Sheesham	Tube well no. 5	18	16	Third week of April (during Incubation)	Twigs, rags and sticks	2	42- 44 days	Last week of May

Plate 17: **(a) Nest of Black Kite on Banyan tree (b) Black Kite Sitting for incubation (c) Nestling sitting near nest (d) Black Kite sitting for incubation in nest on Sheesham tree (e,f) Black Kite sitting for incubation in nest on Pipal tree**

On Sheesham

Black kite was observed sitting the fully constructed nest on Sheesham tree during the third week of April. Nesting structure was located at a height of 16m and height of tree was 18m from ground. Nesting structure was almost similar to the one found on Pipal and Banyan tree; consisting of twigs, rags and sticks. Two chicks were visible in the nest. Chicks were raised for about 40 days and fledging took place after 42-44 days of hatching. Nest was vacated in the last week of May (Plate 17).

4.2.2 Nesting of House Crow

On Pipal

Three nests of House Crow were recorded on Pipal tree from June to August. All the three nests were found at location I (Table 20). Nest was made of dry sticks held in forked branches of tree. One nest was found in the area of Agronomy farm and other two nests were recorded on single tree in the area of poultry farm. Nest 1was found at site of Agronomy farm and was situated at the height of 17 m from ground where as height of tree was 19 m from ground. Construction of nest 1 was started on second week of June and was continued for 11-13 days by both the sexes. Structural composition of nest was a rough platform of dry sticks and rags held safely in branches of tree. Nest 2 and 3 were found on same Pipal tree situated at the area of Poultry farm. Nest 2 was recorded in the third week of June while nest 3 was recorded in the third week of July. Height of nest 1 was 17 m and of nest 2 and 3 was 18m and 20 m respectively. Preparation of both nest 2 and 3 was completed from 10-14 days. Nesting material of all the three nests was same. Incubation of nest 1 and 2 lasted for 15-16 days and of nest 3 was observed for 18 days. Nestlings were raised in the nests for about 13-14 days. Fledging of nestlings occurred after 29 days of hatching in nest 1, 28 days in nest 2 and after 31 days in nest 3. Clutch size 2 was observed in all the three nests (Plate 18).

On Banyan

Nest of House Crow was observed on Banyan tree in the fourth week of June. In northern hemisphere of India, species breeds from March – August, chiefly just before the onset of main monsoon (Goodwin 1976). Nest construction began on 25 June. It took 10-13 days for nest construction which was made up of dry sticks held in forked branches of tree. Height of tree was 21 m and of nesting structure was 10 m. Observed clutch size was 3. Authors Putto and Archer (2003) reported 3-5 eggs per clutch. Incubation period was of 16-17 days and fledging of young ones took place 25 days after hatching. Fry *et al* (2000) reported fledging period as 27-38 days after hatching whereas Cramp and Perrins (1994) reported as 21-28 days.

On Neem

One nest of House Crow was observed on Neem tree in the fourth week of June at location 1 near tube well no 8. Nest was made up to dry sticks and twigs. It took about 11-14

Table 20: Nesting of House Crow

Nest Sr.No.	Tree	Site	Nest sighted	Tree height (m)	Nest height (m)	Nest status	Nest material	Construction of nest (days)	Clutch size	Incubation (days)	Fledging (days after hatching)	Nest vacated
1	Pipal	Agronomy farm	Second week of June	19	17	Under construction	Dry sticks and rags	11-13	2	15-16	29	Second week of August
2	Pipal	Poultry farm	Third week of June	21	18	Under construction	Dry sticks and rags	10-13	2	15-16	28	Third week of August
3	Pipal	Poultry farm	Third week of July	21	20	Under construction	Dry sticks and rags	11-14	2	18	31	First week of September
4	Banyan	Tube well no. 1	Fourth week of June	21	10	Under construction	Dry sticks	10-13	3	16-17	25	Fouth week of August
5	Neem	Tube well no. 8	Fourth week June	14	9	Under construction	Rough platform of dry sticks, twigs and rags	11-14	2	16-18	31	Fouth week of August
6	Jamun	Fisheries area	First week of July	12	8	Under construction	Dry sticks and rags	12-14	2	15-17	29	Last week of August

Plate 18: **(a,b) Nest of House Crow on Pipal tree (c) Nestling sitting near nest on Pipal tree (d) Nest of House Crow on Jamun tree (e) House Crow sitting for incubation on Jamun tree (f) House Crow sitting for incubation in nest on Neem tree**

Plate 19 **(a) Nest of Asian Pied Starling on Mulberry tree (b) Fully constructed nest of Asian Pied Starling on Mulberry tree (c) Asian Pied Starling sitting near nest on Mulberry (d) Spotted Owlet in cavity of Banyan tree**

days for nest construction. Nest was situated at the height of 9 m from ground and height of tree was 14m from ground. Clutch size was 2. Incubation of eggs lasted for about 16-18 days and voices of nestlings were heard 10 days after hatching. Nestlings were raised in nest for about 15 days. Fledging was seen 31 days after hatching. Nest was vacated during fourth week of August (Plate 18).

On Jamun

Nest of House Crow on Jamun tree was sighted in the first week of July at area of College of Fisheries at location I. Height of tree was 12 m from ground and height of nest was 8 m from ground. Nesting structure was composed of dry sticks, rags and pieces of paper. Nest construction was completed in 12-14 days. Duration of incubation was observed for 15-17 days. Nestlings were raised in the nest for 16-19 days. After 29 days of hatching they abandoned the nest. Nest was vacated in the last week of August (Plate 18).

4.2.3 Nesting of Asian Pied Starling

Nesting of Asian Pied Starling was observed on Mulberry tree at location I at the site of poultry area. Nest construction was started in first week of May at the height of 6 m from ground. Construction of closed nest made up of wheat straw, ribbons and grasses was completed in 12-13 days (Table 21) (Plate 19).

Table 21: Nesting of Asian Pied Starling

Tree	Site	Nest sighted	Tree Height (m)	Nest height (m)	Nest status	No. of days to complete nest	Feeding (days)	Nest abandoned
Mulberry	Poultry farm	First week of May	6.6	6	Under construction	12-13	20-21	Third week of June

Nest of Asian Pied Starling was of closed type so no proper incubation and clutch size was visible. Parents were observed taking food material into nest for about 20-21 days. In third week of June nest was abandoned.

4.3.4 Nesting of Spotted Owlet

Already existing cavity on Banyan tree situated at a height of 8m from ground was occupied by a pair of Spotted Owlet and used for breeding. According to Roberts (1992) and Mahmood-ul-Hassan *et al* (2007), the Spotted Owlet is non–excavator. Thus, uses tree cavities, cracks and recesses in building walls, rocks and cliffs as nests Insect (Plate 19).

Height of tree was measured 21m. Pair occupied the cavity in the third week of January. Two nestlings were observed peeping out of the nest in first week of April. In last week of April they vacated the nest. Tree was used as a roosting site by the owls after the successful breeding (Table 22).

Table 22: Nesting of Spotted Owlet

Sr No.	Tree	Location	Nest sighted	Tree height (m)	Nest height (m)	Nest type	Clutch size	Feeding (days)	Fledging
1.	Banyan	Tube well no. 1	Third week of January	21	8	Cavity	2	26	Last week of April

4.2.5 Nesting of Oriental Magpie-Robin

Nest of Oriental Magpie-Robin was observed in month of April in all ready existing cavity in Mulberry tree. Ali & Ripley (2001) also reported that Magpie Robin is a secondary cavity-nester that uses naturally occurring tree cavities for nesting (Plate 20).

Table 23: Nesting of Oriental Magpie-Robin

Tree	Location	Nest sighted (m)	Tree height (m)	Nest height (m)	Nest type	Nesting material	Construction of nest (days)	Clutch size	Incubation
Mulberry	Poultry farm	Third week of April	6.6	1	cavity	Dry grasses	6-7	5	Abandoned after 7days of incubation

Collection of dry grass and other nesting material in cavity was observed from first week of April for the first time and was continued for 6-7 days. Five eggs of pale blue colour with dark brown spots and oval in shape were observed in the nest in the fourth week of April. Ali and Ripley (2001) have also reported the clutch size varying from 3-6 eggs for the Oriental Magpie-Robin with 3 being an occasional number of eggs in a clutch. Incubation was noticed for 7 days. After that parents were not found incubating eggs. None of the eggs hatched. Causes of leaving nest were not known. Saloni (2010) also found the loss of all the four eggs to unknown causes (Table 23).

At location II

At location II nesting of only two bird species was recorded i.e. Little Brown Dove and Cattle Egret

4.2.6 Nesting of Little Brown Dove

Nest of Little Brown Dove was recorded in the month of June in the peripheral region of location II. Nest was just a small platform made up of dry grass material and sticks held in outer branches of tree. It took about 3-4 days to construct the nest. Both the sexes were involved in nest construction while only one parent plays role in incubation. Height of nest from ground was 4 m while of a tree was 12m from ground. First egg was laid on 13 June and second on 19 June. There was difference of about 6 days in laying of both the eggs. Eggs were white in colour and oval in shape (Plate 20).

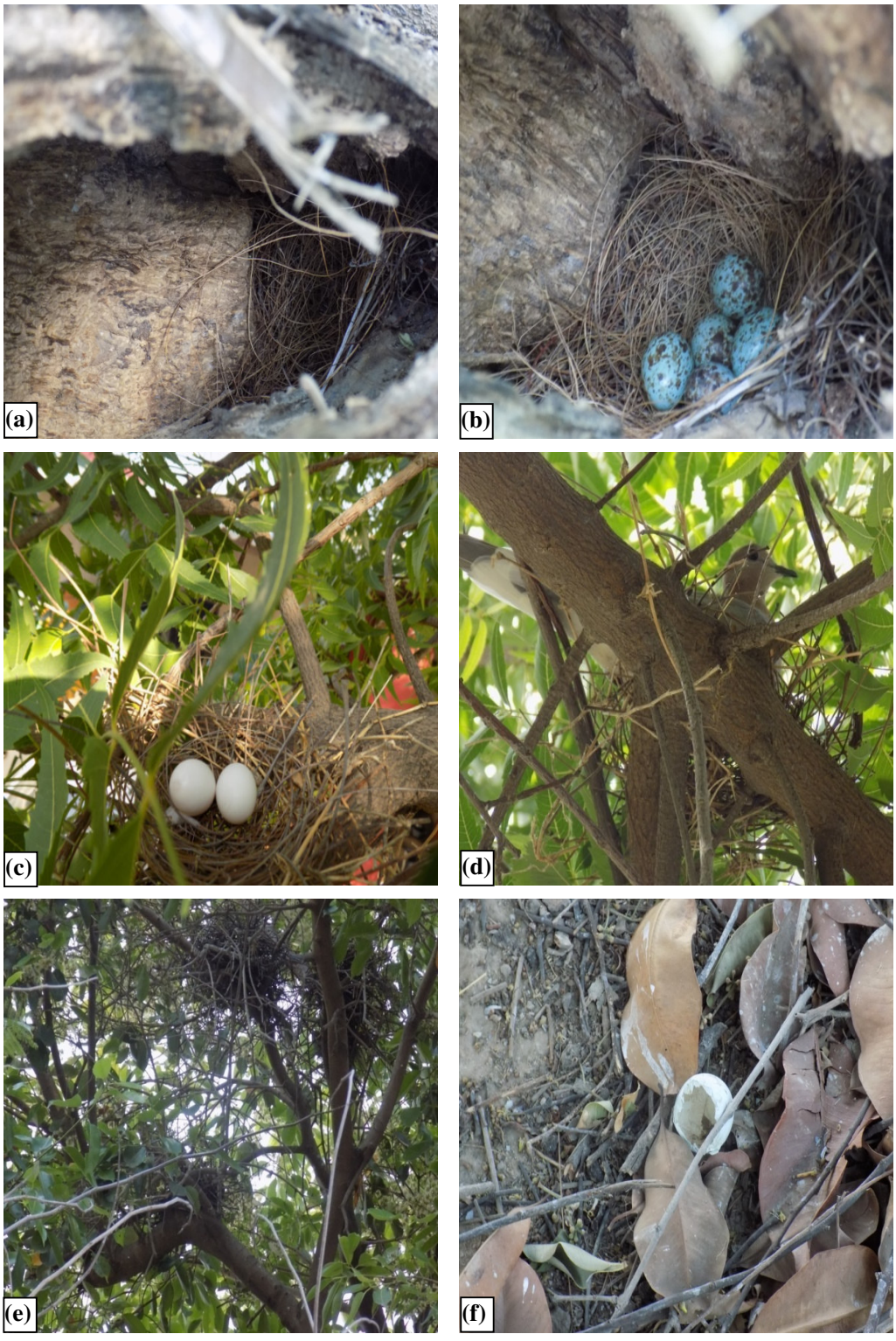

Plate 20: **(a) Nesting material collected in cavity of Mulberry tree by Oriental Magpie-Robin (b) eggs of Oriental Magpie- Robin (c) eggs of Little Brown Dove in nest on Neem tree (d) Little Brown Dove sitting for incubation (e) Nests Of Cattle Egret On Jamun tree (f) Destroyed egg of Cattle Egret.**

Table 24: Nesting of Little Brown Dove

Tree	Location 2	Nest sighted (m)	Tree height (m)	Nest height (m)	Nest material	Construction of nest (days)	Clutch size	Incubation	Fledging (days after hatching)	Nest vacated
Neem	Peripheral area	First week of June	12	4	Sticks and twigs	3-4	2	14-15	24-25	Third week of July

Incubation of first egg was started soon, before laying the second egg. Saxena *et al* (2008) reported that the clutch size in doves was observed to be strictly two eggs. Incubation of eggs was continued for 14-15 days. First egg hatched after 14 days from the day it was laid and second egg hatched 15 days later it was laid. Saxena *et al* (2008) also reported that incubation varies from 13-14 days. Difference of six days was noticed in laying of both the eggs. This finding is contrary to that of Sexena *et al* (2008) who reported the difference of only day in laying of both the eggs. Clutch size and incubation period was similar to the findings of Sexena *et al* (2008). Nestlings were raised in the nest by both the parents for about 17-19 days. Two fully grown young ones were successfully raised and fledging took place 24-25 days after hatching (Table 24) (Plate 20).

4.2.7 Nesting of Cattle Egret

Three nests of Cattle Egret were found on Jamun tree at location II at canal area in the month of April. Out of three nests only one nest was found active. Dry and naked sticks and twigs were used as a nesting material. The findings of Iyer (2004) were also similar for nest building by Egrets. After 6 days egg was found lying on ground. Cattle Egret was not observed near the nest after destruction of eggs. The only reason for destruction of eggs could be the untidy lose nesting structure. Earlier findings of few scientists also claimed that improper and unsafe nesting structure proves to be fatal for youngones and eggs (Plate 20).

Nesting of all the seven species of birds was recorded from April to September. Except Oriental Magpie-Robin and Cattle Egret, other birds shows 100% breeding success. Kruskal-wallis test was used to check if the significant difference among trees for nest preference. No significant different exits among the tree species ($p > 0.05$).

CHAPTER V

SUMMARY

The main objective of present study was to find out the avian diversity and nesting preference of avian species in relation to indigenous trees at two locations, viz; Punjab Agricultural University, Ludhiana and village Machaki Mal Singh, Faridkot from April 2016-April 2017.Six indigenous trees; Banyan (*Ficus benghalenesis*), Jamun (*Syzgium cumini*), Mulberry (*Morus alba*), Neem (*Azadirachta indica*), Pipal (*Ficus religiosa*) and Sheesham (*Dalbergia sissoo*) were selected at two different locations. Point count method was followed for study. Association of birds with trees was observed. Birds show an intimate relationship with trees as trees are used by them for various purposes, for example for foraging, roosting, courtship, breeding and shelter.

Total 52 bird species were recorded on all the six tree species selected. Out of which 12 were found on Sheesham, 22 on Neem, 23 on Banyan, 32 on Pipal, 33 on Mulberry and 17 on Jamun tree. Birds richness was highest on Mulberry and lowest on Sheesham. Common Myna, House Crow and Rose-ringed Parakeet were the abundant species on all trees under study. Abundance of birds is affected by the availability of fruits on trees of genus *Ficus* and mulberry. Fruiting on selected trees attracted more birds showing more species richness in fruiting months. All frugivorous and omnivorous birds increased in abundance with the availability of ripe fruits. In case of Jamun and Sheesham tree, abundance of birds was higher at the stage when new foliage starts appearing and at flowering stage. Species richness was comparatively low at the fruiting stage. Local migrants were frequently observed during the fruiting seasons of trees.

Banyan and Pipal trees present adjacent to field area were often used by the birds for perching in-between the feeding bouts on Maize and Bajra crops in the nearby fields. Abundance of *Ficus* spp. Can provide alternative food resource to birds and can reduce damage to nearby by crops. Therefore, plantation of *Ficus* and other fruiting trees should be undertaken wherever possible.

Kruskal-wallis test was carried out to find if there was significant difference of bird diversity among tree species of location I and II separately. Significant difference exists only among tree species of location 1 ($p<0.05$). This difference may be due to presence of different vegetation at different sites at location I whereas at location II same vegetation was present around all the trees. Mann-witney test was carried out to know if there was significant difference of bird diversity among individual tree species between location 1 and 2. Significant difference exists only in case of Neem tree. It may be due to difference in crown size of trees selected at both the locations. Crown size of Neem trees at location I was comparatively less than the Neem trees at location II.

Studies on nest site selection provide information about breeding requirements/ habitats. Such information could be beneficial for management purposes. Nests height, nest location, nesting tree, nesting time and tree height were measured. Nesting of 7 bird species was recorded on selected trees. Nesting of 5 species was found at location I while only of 2 was found at location II. Total 14 nests were recorded. Three nests of Black Kite, 6 of House Crow, 1 of Spotted Owlet, 1 of Little Brown Dove, 1 of Oriental Magpie-Robin, 1 of Pied Myna, 1 of Cattle Egret. Out of 14 nests recorded, four nests were found on Pipal tree, 3 on Banyan tree, 2 on Mulberry, 2 on Jamun, 2 Neem and 1 on Sheesham. Breeding of all the 7 birds took place from April to August. Tall trees (Banyan, Pipal and Sheesham) with dense foliage are preferred by large birds for nesting e.g Black Kite and House Crow. Trees with less height (Mulberry) are preferred by small birds for nesting like Pied Myna and Oriental Magpie Robin. Cavities in the trees (Mulberry) are used by birds for nesting and roosting e.g Spotted Owlet and Oriental Magpie Robin.

Kruskal-wallis test was carried out to find if there was significant difference for preference of nesting among tree species. No significant difference was recorded.

Bare trees after shedding of leaves were used by flocks of birds for roosting. Species richness was observed more in morning hours than in evening. Flocks of birds were usually observed in evening time.

Depletion of indigenous tree cover and invasion of exotic tree species directly affects the distribution of avian fauna. Old and indigenous trees account to be an important substrate for nesting in the form of dense canopies and cavities. Indigenous trees must be promoted over exotic ones because the services provided by them are already part of local ecology.

REFERENCES

Abrams M D and Rodewald A D (2002) Floristics and avian community structure: implications for regional changes in eastern forest composition. *Forest Sci* **48:**267-72.

Aggarwal S, Sahi D N and Wani A A (2008) Feeding guilds of avifauna of Nandini Wildlife Sanctuary, Jammu. *Environ Sci* **2:**157-60.

Aitken K, Wiebe K Martin K (2002) Nest-site reuse patterns for a cavity-nesting bird community in interior British Columbia. *Auk* **119:** 391–402.

Alerstam T (1990) *Bird migration*. Cambridge University Press, Cambridge.

Ali S (ed) (2002) *The book of Indian birds*. pp 1-402. Oxford University Press, Bombay.

Ali S and Ripley S D (1983) *Handbook of Birds of the India and Pakistan.* Vol. 4, pp 99-113. Oxford University Press, Delhi.

Ali S, Allah Rakha B, Hussain I, Nadeem M S and Rafique M (2013) Ecology of Feral Pigeon (*Columba livia*) in urban areas of Rawalpindi/Islamabad, Pakistan. *Pak J Zool* **45:**1229-34.

Ali Sand Ripley S D (2001) *Handbook of the birds of India and Pakistan, together with those of Bangladesh, Nepal, Bhutan and Sri Lanka.* Oxford University Press, New Delhi.

Andheria A P (2002) Roosting behaviour of Common Tailorbird *Orthotomus sutorius* (Pennant). *J Bombay Nat Hist Soc* **99:**312-16.

Andren H (1992) Corvid density and nest predation in relation to forest fragmentation: a landscape perspective. *Ecol* **73:**794-804.

Andren H (1994) Effect of habitat fragmentation on birds and mammals in landscapes with different proportions of suitable habitat. *Oikos* **71:**355-66.

Angelstam P and Mikusinski G (1993) Woodpecker assemblages in natural and managed boreal and hemiboreal forest – a review. *Ann Zool Fennici* **31:**157-72.

Ansell F A, Edwards D P and Hamer K C (2011) Rehabilitation of logged rain forests: Avifaunal composition, habitat Structure, and implications for biodiversity-friendly REDD+. *Biotropica* **43:**504-11.

Anthony R G and Issacs F B (1989) Characteristics of Bald Eagle nests in Oregon (USA). *J Wildl Manag* **53:**148-59.

Arora A, Kumar M and Kler T K (2016) Avian diversity in urban, periurban and rural residential areas of Ludhiana. *J Appl Sci* **6:**478-79.

Ashkenazi S and Dimentman C (1998) Foraging, nesting and roosting habitats of the avian fauna of the Agmon wetland, northern Israel. *Wetlands Ecol Manag* **6:**169–87.

Aslan C E and Rejmanek M (2010) Avian use of introduced plants: Ornithologist records illuminate interspecific associations and research needs. *Ecol Appl* **20(4):**1005-20.

Augenfeld K H, Franklin S B and Nyder D H (2008) Breeding bird communities of upland hardwood forest 12 years after shelterwood logging. *Forest Ecol Manag* **225:** 1271-82.

Barrows C (1981) Roost selection by spotted owls and adaptation to heat stress. *Condor* **83(4):**302-09.

BirdLife International (2008) Birds occur in all major habitat types, with forest being particularly important. Presented as part of the BirdLife State of the world's birds website. http://www.birdlife.org/datazone/sowb/casestudy/172.

Boumaaza O, Bara M, Dhaya El-Hak Khemis M, Boucherit K, Elafri A, Bouslama Z and Houhamdi M (2016) Breeding biology of the black kite *Milvus migrans* (Accipitridae) at Ras El Ma ravine (Guelma, northeast Algeria). *J Entmol Zool Stud* **4(5):**480-83.

Brandt J S, Kuemmerle T, Li H (2012) Using Landsat imagery to map forest change in southwest China in response to the national logging ban and ecotourism development. *Remote Sens Environ* **121:**358-69.

Brazaitis G, Roberge J M, Angelstam P, Marozas V and Pėtelis K (2005) Age-related effects of clearcut ─ old forest edges on bird communities in Lithuania. *Scand J Forest Res* **20(6):**59-68.

Brockerhoff E, Jactel H and Parrotta J (2008) Plantation forests and biodiversity: oxymoron or opportunity? *Biodivers Conserv* **17:**925-51.

Bruford M W (2002) Biodiversity-Evolution, species, Genes. In: Norris K and Pain D J (ed) *Conserving Birds Biodiversity-General Principals and their Application*. pp 1-9. Cambridge University Press, U.K.

Buckley F G and Buckley P A (1968) "Upside-down Resting by Young Green-Rumped Parrotlets (*Forpus passerinus*)". *Condor* **70:**89.

Buckley H L and Freckleton R P (2010) Understanding the role of species dynamics inabundance–occupancy relationships. *Ecology* **98:**645-58.

Bull E L and Copper (1991) Vaux's Swiftnests in hollow tree. *West Birds* **22:**85-91.

Bull E L, Wright A L and Henjum M G (1989) Nesting and diet of Long-eared Owl in conifer forests, Oregon (USA). *Condor* **91:**908-12

Bunnell F L (2013) Sustaining Cavity-Using Species: Patterns of Cavity Use and Implications to Forest Management. *ISRN Forestry*. Article ID 457698, 33 pages http://dx.doi.org/10.1155/2013/457698

Burgess N D, Doggart N and Lovett J (2002) The Uluguru Mountains of EasternTanzania: the effect of forest loss on biodiversity. *Oryx* **36:**140-52.

Chace J F and Walsh J J (2006) Urban effects on native avifauna: a review. *Landsc Urban Plan* **74:**46-69.

Chakravarty S and Sandhu J S (2002) Bird community of flowering Indian coral tree *Erythrina indica*. *Ind J Environ Ecoplan* **6:**13-18.

Cintra R and Naka L N (2012) Spatial variation in bird community composition in relation to topographic gradient and forest heterogeneity in a central Amazonian rainforest. *Int Ecol* 34-36. http://dx.doi.org/10.1155/2012/435671

Collias N E and Collias E C (1984) *Nest building and bird behaviour*. pp 8-37. Princeton University Press, New Jersey, USA.

Cordeiro N J (2005) Does forest fragmentation impact mixed species foraging bird flocks in Tanzania forest. In TAWIRI. *Proc 5th Annual Scientific Conference.* pp 157-65, Arusha, Tanzania.

Coulson R N and Witter J A (1984) *Forest entomology: ecology and management.* Pp. 1-688. John Wiley & Sons, New York, USA.

Cramp S and Perrniss C M (1994*) Handbook of the Birds of Europe, the Middle East and North Africa: The Birds of Western Palearctic*. Vol 8. Oxford Univ Press, Oxford.

DeGraaf R M and Yamasaki M (2003) Options for managing early-successional forest and shrubland bird habitats in the northeastern. *Forest Ecol Manag* **185:**179-91.

Dhadse S, Kotangale J P Chaudhari P R and Wate S R (2009) Diversity of birds at Panipat refinery, Haryana (India). *Environ Monit and Assess* **158:**1-8.

Dhindsa M S (1980) *Ecological studies on the Weaver birds of the Punjab their control*. Ph.D. dissertation. Punjab Agricultural University, Ludhiana, India.

Dhindsa M S, Komer P E and Boag D A (1989) Nest height of Black-billed Magpies: Is it determined by human disturbance or habitat type? *Can J Zool* **67:**228-32.

Dhindsa, M S, Sandhu J S, Sandhu P S and Toor H S (1988) Roadside birds in Punjab (India): relation to mortality from vehicles. *Environ Conserv* **15:**303-10.

Diaz L (2006) Influences of forest type and forest structure on bird communities in oak and pine woodlands in Spain. *Forest Ecol Manag* **223:**54-65.

Dickson J G, Conner R N, Fleet R R, Jackson J A and Kroll J C (ed) (1979) *The role of Insectivorous Birds in Forest Ecosystem*. pp 1-18. Academic Press, New York.

Dodia P P (2011) Roost tree selection by Common Indian Peafowl *Pavo cristatus* at Bhavanagar, Gujarat (India). *Life sci Leafl* **11:**346-54.

Doggart N, Lovett J, Mhoro B, Kiure J and Burgess N (2005) Biodiversity surveys in the Forest Reserves of the Uluguru Mountains. Technical paper for The Wildlife Conservation Society of Tanzania and Tanzanian Forest Conservation Group. DSM, Tanzania. pp 8-18.

Faanes C A (1987) Breeding birds and vegetation structure in western worth Dakota (USA) wooded draws. *Prairie Nat* **19:**209-10.

Farina A (1989) Bird community patterns in Mediterranean farmlands: a comment. *Agric Ecosys Environ* **27:**177-83.

Farwig N, Sajita N and Bo¨hning-Gaese K (2008) Conservation value of forest plantations for bird communities in western Kenya. *Forest Ecol Manag* **255:**3885-92.

Fennessy G J and Kelly T C (2006) Breeding densities of Robin Erithacus rubecula in different habitats: the importance of hedgerow structure. *Bird Study* **53:**97-104

Fernandez J E, Jimenez M D and Lucas E (2002) Factors affecting intra- and inter-specific variations in the difference between alert distances and flight distances for birds in

forested habitats. *Can J Zool* **80:**1212-20.

Fielder P C and Starkey R G (1986) Bald Eagle *Haliaeetus Leucocephalus* perch sites in eastern Washington (USA*). Northwest Sci* **60:**186-90.

Fisher R J, Fletcher Q E , Willis C K R and Brigham R M (2004) Roosting selection and roosting behavior of male Common Night hawk*s. Am Mid Nat* **151:**79-87.

Flanders A A, Kuvlesky W P, Ruthven D C, Zaiglin R E, Bingham R L, Fulbright T E, Hernandez F & Brennan L A (2006) Effects of invasive exotic grasses on South Texas rangeland breeding birds. *The Auk* **123:**171-82.

Fleishman E, McDonal N, Mac Nally R, Murphy D D, Walters J and Floyd T (2003**)** Effects of floristics, physiognomy and non-native vegetation on riparian bird communities in a Mojave Desert watershed. *J Anim Ecol* **72:**484-90.

Ford H A, Koske S and Bridges L (1986) Foraging of birds in eucalypt woodland in northeastern New South Wales. *Emu* **86**:168-79.

Forget P M, Munoz E and Leigh J E G (1994) Predation by rodents and bruchid beetles on seeds of Scheelea palms on Barro Colorado Island, Panama. *Biotropica* **26:**420-26.

French K, Major R E and Hely K (2004) The role of nectarproducing plants in attracting birds to gardens *Biol Conserv* **121:**545-59.

French K, Major R E and Hely K (2005) Use of native and exotic garden plants by suburban nectarivorous birds. *Biol Conserv* **121:**545-59.

Fry C H, Keith S and Urban E K (2000) *The birds of Africa*. Vol 6. Academic Press, London.

Gabbe A P, Robinson S K and Brawn J D (2002) Tree species preferences for foraging insectivorous birds: implication for floodplain forest restoration. *Conserv Biol* **16:**462-70

Gajera, N, Dave S M and Dharaiya N A (2009) Nesting patterns of some terrestrial birds in Danta Forest Range, northern Gujarat, India. *J Threatened Taxa* **1:**313-14.

Garcia B P, Yorio P, Moreno J and Potti J (2008) Seasonal decline inbreeding performance of the Kelp Gull *Larus dominicanus*. *Mar Ornithol* **36:**153-15.

Gawlik D S and Bildstein K L (1990) Reproductive success and nesting habitat of Loggerhead Shrikes in N-C South Carolina (USA). *Wilson Bull* **102:**37-48.

Germaine S S, Rosenstock S S, Schweinsburg R E and Richardson W S (1998) Relationships among breeding birds, habitat, and residential development in greater Tuscon, Arizona. *Ecol Appl* **8:**680-91.

Giese C L A and Cuthbert F J **(**2003) Influence of surrounding vegetation on woodpecker nest tree selection in oak forests of the Upper Midwest USA. *Forest Ecol Manag* **179:**523-34.

Giller P S (1984) *Community Structure and the Niche.* Chapman and Hall, London.

Goetz S, Steinberg D, Dubayah R and Blair B (2007) Laser remote sensing of canopy habitat heterogeneity as a predictor of bird species richness in an eastern temperate forest, USA. *Remote Sens Environ* **108:**254-63.

Goodwin D (1976) *Crows of the World*. Pp. 17-19. Britiish Museum and Cornell University Press, London and Ithaca, New York.

Gregory R, Baillie S and Bashford R (2004) Monitoring breeding birds in the United Kingdom. I: Anselin A (ed) *Proc International Conference* and 13th Meeting of the European Bird Census Council, Parnu. *Estonia Bird Census News* **13:**101-02.

Grove S J (2001) Saproxylic insect ecology and the sustainable management of forests. *Annu Rev Ecol Syst* **33(1):**1-33.

Gupta S K, Kumar P and Malik M K (2009) Avifaunal diversity in the University Campus of Kurukshetra, Haryana. *J Threatened Taxa* **1:**629-32.

Hahn D C and Hatfield J S (1995) Parasitism at the landscape scale: cowbirds prefer forests. *Conserv Biol* **9:**1415-24.

Hartley M J (2002) Rationale and methods for conserving biodiversity in plantation forests. *Forest Ecol Manag* **155:**81-95.

Heath M F and Evans M I (2000) Important bird areas in Europe: Priority sites for conservations. *BirdLife Int* **10(2):**310-11.

Herrera C M (1985*) Habitat*-consumer interaction in frugivorous birds. In: Cody M L (ed) *Habitat Selection in Birds.* Pp 341-65Academic Press, New York.

Hinsley S A, Hill R A, Fuller R J, Bellamy P E and Rothery P (2009) Bird species distributions across woodland canopy structure gradients. *Commun Ecol* **10:**99-110.

Holmes R T and Schultz J C (1988) Food availability for forest birds: effects of prey distribution and abundance on bird foraging. *Can J Zool* **66:**720-28.

Holmes R T and Sherry T W (2001) Thirty-year bird population trends in an unfragmented temperate deciduous forest. *Forest Ecol Manag* **155:**91-95.

Honkanen M J, Roberge M, Rajasarkka A and Monkkonen M (2010) Disentangling the effects of area, energy and habitat heterogeneity on boreal forest bird species richness in protected areas. *Global Ecol Biogeogr* **19:**61-71.

Huste A and Boulinier T (2011) Determinants of bird community composition on patches in the suburbs of Paris, France. *Biol Conserv* **144:**243-52.

Imbeau L, Desrochers A, Jan N, and Desrochers A (2014) Foraging Ecology and Use of Drumming Trees by three-toed woodpecker. *J Wildl Manag* **66:**222-31.

Iyer M K (2004) Nesting of Phalacrocoracidae, Threskiornithidae and Ardeidae at Ahmedabad Zoo. *Newsletter for Birdwatchers* **44(3):**43-44.

Jankowski J E, Ciecka A L, Meyer N Y and Rabenold K N (2009) Beta diversity along environmental gradient: implications of habitat specialization in tropical montane land scapes. *J Anim Ecol* **78:**315-27.

Jerath N P and Chadha J (2006) *Biodiversity in the Shivalik Ecosystem of Punjab*. Pp 1-193. University of Chicago Press, Dhera Dun.

Jimenez J E and Conover M R (2001) Ecological approaches to reduce predation on ground-nesting game birds and their nests. *Wildlife Soc B* **29:**62-69.

Jokimaki J (1999) Occurrence of breeding bird species in urban parks: Effects of park structure and broad- scale variables. *Urban Ecosys* **3:**21-34.

Joshi K and Bhatt D (2013) Avian species distribution in different elevation zone forest (Sal, Pine Mixed and Oak) in Nainital district of Uttarakhand, India. *Russ J Ecol*+ **44:**71-79.

Kachare V S, Pawar R S and Panaskar D B (2011) Disturbances on the living of birds and their population in Wetlands of Kolhapur City, Maharashtra (India). *Eur J Exp Biol* **1:**43-50.

Kaur A (2005) *Behavioural Ecology of Common Myna, Acridotheres tristis*. M.Sc. thesis, Punjab Agricultural University, Ludhiana, India.

Kennedy C E J and Southwood T R E (1984) The number of species of insects associated with British trees: a re-analysis. *J Appl Ecol* **53:**455-78.

Kennedy P L, DeBano S J, Bartuszevige A M and Lueders A S (2009) Effects of native and non native grassland plant communities on breeding passerine birds: Implications for restoration of Northwest Bunchgrass Prairie. *Restor Ecol* **17:**515-25.

Khan H A and Beg M A (1998) Roost and Roosting Habits of Rose-ringed Parakeet (*Psittacula krameri*) in Central Punjab, (Pakistan). *Pak J Biol Sci* **1:**37-38.

Khan T N (2003) Temporal changes on the abundance and community structure of migratory birds in Santragachhi Lake, West Bengal, and their relationship with water hyacinth cover. *Current Sci* **99:**1570-77.

Kler T K and Kumar M (2015) Prevalance of bird species in relation to food habits and habitat. *J Agr Res* **52:**50-53.

Kler T K, Vashishat N and Kumar M (2015) Bird composition in urban landscape of Punjab. *Int J Adv Res* **3:**1113-18.

Korine C, Kalko E K and Herre E A (2000) Fruit characteristics and factors affecting fruit removal in a Panamanian community of strangler figs. *Oecologia* **123:**560-68.

Kormondy E J (2004) *Concepts of Ecology*. Pp 1-504. Prentice Hall of India Pvt Ltd, New Delhi.

Krebs C J (1985) The experimental analysis of distribution and abundance. Ecology. Pp. 513-42, Harper and Row, New York.

Lambert F (1989) Fig eating birds in Malaysian lowland rain forest. *J Trop Ecol* **5:**401-12.

Land D, Marion W R, and Meara T E O (1989) Snag availability and cavity nesting birds in slash pine plantation. *J Wildl Maang* **59:**1165-71.

Lantschner M, Rusch V and Peyrou C (2008) Bird assemblages in pine plantations replacing native ecosystems in NW Patagonia. *Biodivers Conserv* **17:**969-89.

Lee P Y and Rotenberry J T (2005) Relationships between bird species and tree species assemblages in forested habitats of eastern North America. *J Biogeogr* **32:**1139-50.

Levey D J and Stiles F G (1992) Evolutionary precursors of longdistance migration-resource availability and movement patterns in neotropical landbirds. *Am Nat* pp. 447-76.

Lewke R E (1982) A comparison of foraging be-havior among permanent, summer, and winter resident bird groups. *Condor* **84:**84-90.

Lind J and Cresswell W (2006) Anti-predation behaviour during bird migration; the benefit of studying multiple behavioural dimensions. *J Ornithol* **147:**310-16.

Lindenmayer D B, Cunningham R B, Donnelly C F, Nix H and Lindenmayer B D (2002) Effects of forest fragmentation on bird assemblages in a novel landscape context. *Ecol Monogr* **72:**1-18.

Lynas P, Newton S F and Robinson J A (2007) The status of birds in Ireland: an analysis of conservation concern 2008–2013. *Irish Birds* **8:**149-67.

Ma Z J, Gan X J, Cai Y T, Chen J K and Li B (2011) Effects of exotic *Spartina alterniflora* on the habitat patch associations of breeding saltmarsh birds at Chongming Dongtan in the Yangtze River estuary, China. *Biol Invasions* **13:**1673-86.

MacArthur R H and MacArthur J W (1961) On bird species diversity. *Ecology* **42(3):**594-98.

MacArthur R H, Recher H and Cody M (1966) On the relation between habitat selection and species diversity. *Am Nat* **100:**319-32.

Magura T, Ba´ldi A and Horva´th R (2008) Breakdown of the species–area relationship in exotic but not in native forest patches. *Acta Oecol* **33**:272-79.

Maheswaran G (2001) Effects of habitat alteration on the birds of the Western Ghats, India. *Oriental Bird Club Bulletin* **33:**13-14.

Mahmood-ul-Hassan M, Beg M A, Mushtaq-ul-Hassan M and Rana S A (2007) Nesting and breeding habits of the Spotted Owlet (*Athene brama*) in Punjab, Pakistan. *J Rapt Res* **41:**50-52.

Malhi C S (2006) Status of Avifauna in Agricultural Habitat and other associated sub-habitats of Punjab. *J Environ Ecol* **24:**131-43**.**

Manakadan A and Pittie A (2002) Standardized English and scientific names of the birds of the Indian subcontinent. *Newsletter for Birdwatchers* **42(3):**1-36.

Manhães M A and Ribeiro A L (2005) Spatial Distribution and Diversity of Bird Community in an Urban Area of Southeast Brazil. *Int J* **48:**285-94.

Manna A K (2010) Review: Indian national tree (*Ficus bengalensis*). *Int J Pharm Life Sci* **1:**268–73.

Martin T E and Li P (1992) Life history traits-open vs. cavity nest birds. *Ecol* **73:**579-952.

Marwaha A (2015) *Urban Ecology of Delhi: Relationship between birds and trees in urban green spaces and their management*. M.Sc. Thesis. TERI University, New Delhi.

Marzluff J M (2005) Island biogeography for an urbanizing world: How extinction and colonization may determine biological diversity in human-dominated landscapes. *Urban Ecosys* **8:**157-77.

Mathew D N, Narendran T C and Zacharias V J (1983) A comparative account of the food habits of some species of birds affecting agriculture. *J Bombay Nat Hist Soc* **75:**1178-97.

Matlock R B and Edwards P J (2006) The influence of habitat variables on bird communities in forest remnants in Costa Rica. *Biodivers Conserv* **15:**2987-3016.

McKinney M L (2005) Urbanization as a major cause of biotic homogenization. *Biol Conserv* **127:**247-60.

McShea W J, Healy W M, Devers P, Fearer T, Koch F H Stauffer D and Waldon J (2007) Forestry matters: decline of oaks will impact wildlife in hardwood forests. *J Wildl Manag* **71:**1717-28.

Mehta K S, Patyal S K, Rana R S, Sharma K C (2010) Ecofriendly techniques for the management of *Helicoverpa armigera* (Hubner) in tomato. *J Biopesticides* **3:**296-303.

Melles S (2005) Urban bird diversity as an indicator of human social university and economic inequality in Vancouver, British Columbia. *Urban Habitat* **3:**25-48.

Melles S, Glenn S and Martin K (2003) Urban bird diversity and landscape complexity: species-environment associations along a multiscale habitat gradient. *Conserv Ecol* **7:**5-8.

Meyburg B U (1971) On the question of the incubation period of Black Kite *Milvis migrans*. *Ibis* **113:**530.

Mills G S, Dunning J B and Bates J M (1989) Effects of urbanization on breeding bird community structure in southwestern desert habitats. *Condor* **91:**416–28.

Monkkonen M R, Tornberg and Vaisanen P (2000) Proximity to Goshawk nest may reduce predation rates on birds' nests. *Wildlife in Finland* **46**:27-36.

Moore F R and Yong W (1991) Evidence of food-based competition among passerine migrants during stopover. *Behav Ecol Sociobiol* **28:**85-90.

Moser E B, Barrow W C and Hamilton R B (1990) An exploratory correspondence analysis of avian foraging behavior-habitat relationships. *J Avian Biol* **13:**309-17.

Mudappa D (2000) Breeding biology of the Malabar Grey Hornbill (*Ocyceros griseus*) in Southern Western ghats, India. *J Bombay Nat Hist Soc* **97:**15-24.

Murakami M (1998) Effect of avian predation on survival of leaf-rolling lepidopterous larvae. *Res Popul Ecol* **41:**135-38.

Murgui E (2010) Seasonality and nestedness of bird communities in urban parks in Valencia, *Spain Ecography* **33:**979-84.

Nairn R and O'Halloran J (2012) *Bird habitats in Ireland.* pp 196-212. The Collins Press, Cork.

Naithani A and Bhatt D (2012) Bird community structure in natural and urbanized habitats along an altitudinal gradient in Pauri district (Garhwal Himalaya) of Uttarakhand state, India. *Biologia* **67:**800-808.

Nan W, Fei J and Guangmei Z (2006) Nest site selection of White-eared pheasant in southwestern Sinchuan Province, China. *Front Biol China* **1:**66-70.

Natarajan V (1997) Breeding biology of the Southern Crow-Pheasant *Centropus sinensis parroti* Stresemann (Aves: Cuculidae) at Point Calimere, Tamil Nadu. *J Bombay Nat Hist Soc* **94:**56-63.

Neelakantan K K (1976) Seasonal variations in the occurrence of non-migratory birds. *Newsletter for Birdwatchers* **16(2):**5-6.

Nikolov S C (2009) Effect of stand age on bird communities in latesuccessional Macedonian pine forests in Bulgaria. *Forest Ecol Manag* **257:**580-87.

Nogales M, Valido A, Medina F M and Delgado J D (1999) Frugivory and factors influencing visitation by birds at 'Balo' (plocama pendula Ait., Rubiaceae) plants in the canary islands. *Ecosci* **6:**531-38.

Norbu N, Wikelski M C, Wilcove D S, Partecke J, Ugyen, Tenzin U, Sheru and, Tempa T (2013) Partial altitudinal migration of a Himalayan Forest pheasant. *PLoS One* **8(4):** e60979.

Norris D R, Marra P P, Kyser T K, Sherry T W and Ratcliffe L M (2004) Tropical winter habitat limits reproductive success on the temperate breeding grounds in a migratory bird. *Biol Sci* **271:**59-64.

Oleti S (2010) Parsons H, Major R E and French K Species interactions and habitat associations of birds inhabiting urban areas of Sydney, Australia. *Austral Ecol* **31:** 217-27.

Oostra V, Gomes L G L and Nijman V (2008) Implications of deforestation for the abundance of restricted-range bird species in a Costa Rican cloud-forest. *Bird Conserv Int* **18:** 11-19.

Pandey D N (1991) Nesting of the Pond heron *Ardeola grayii* (Sykes) on Eucalyptus trees. *J Bombay Nat Hist Soc* **88:**281.

Parasharya B M and Mukherjee A (1999) Roosting behaviour of Indian Peafowl *Pavo cristatus*. *J Bombay Nat Hist Soc* **96:**471-72.

Pennington D N and Blair R B (2011) Habitat selection of breeding riparian birds in an urban environment: Untangling the relative importance of biophysical elements and spatial scale. *J Conserv Biogeogr* **17:**506-18.

Petit L J, Petit D R, Christian D G and Powell H D W (1999) Bird communities of natural and modified habitats in Panama. *Ecography* **22:**292-304.

Pidgeon A M, Radeloff V C, Flather C H, Lepczyk C A, Clayton M K, Hawbaker T J and Hammer R B (2007) Associations of forest bird Species richness with housing and landscape patterns across the USA. *Ecol Appl* **17:**1989-2010.

Pina J P (1989) Breeding bird assemblages in euclayptus plantations in Portugal. *Ann Zool Fenn* **26:** 287-90.

Prajapati S H and Prajapati R P (2012) Observation on roosting habitat of roseringed parakeet (*Psittacula krameri*). *Life sci Leafl* **7:**56-62.

Pulliam H R and Danielson B J (1991) Sources, sinks, and habitat selection: a landscape perspective on population dynamics. *Am Nat* **137:**50-66.

Purcell K L, Verner J (2008) Nest-site habitat of cavity-nesting birds at the San Joaquin Experimental Range. In: Merenlender A, McCreary D D, Purcell K L (ed) *Proceedings 6th Symp on Oak Woodlands: Today's Challenges, Tomorrow's Opportunities.* pp. 279-91. USDA Gen Tech Rep PSW-GTR-217.

Puttoo M and Archer T (2003) Control and/or Eradication of Indian crows (Corvus splendens) in Mauritius. AMAS. *Food Res Counc* **3:**44-47.

Quine C P, Fuller R J, Smith K W and Grice P V (2007) Stand management: a threat or opportunity for birds in British woodland? *Ibis* **149:**161-74.

Ramachandra T V, Bhat H R and Kulkarni G (2014) tree species for planting at the sides and median of the roads in Bengaluru. *ENVIS technical report* pp 42.

RamanT R S, Joshi N V and Sukumar R (2005) Tropical Rainforest bird community structure in relation to altitude, tree species composition, and null models in the Westerm Ghats, India. *J Bombay Nat His Soc* **102:**145-57.

Ramchandra A M (2013) Diversity and richness of bird species in newly formed habitats of Chandoli National Park in Western Ghats, Maharashtra State, India. *Biodiv J* **4:**235-42.

Ranganathan J, Chang K A and Daily G C (2007). Satellite detection of bird communities in tropical countryside. *Ecol Appl* **17:**499-1510.

Rattenborg N C (2006) Do birds sleep in flight? *Naturwissenschaften* **93:**413-25.

Renner S C (2011) Bird species-richness pattern in the greater Himalayan Mountains-a general introduction. *Ornithol Monogr* **70:**1-9.

Richardson J W (1978) Timing and amount of bird migration in relation to weather: a review. *Oikos* **30:**224-72.

Rittiboon K and Karntanut W (2011) Distribution of resident birds in a protected tropical habitat in south Thailand. *J Issaas* **17(2):**95-103.

Roberts T J (1992) *The Birds of Pakistan*. Vol 2, pp. 650-54. Oxford University Press, U.K.

Robinson C, Duinker P N and Beazley K F (2010) A conceptual framework for understanding, assessing, and mitigating ecological effects of forest roads. *Environ Rev* **18:**61-86.

Robinson S K and Holmes R T (1984) Effects of plant species and foliage structure on the foraging behaviour of forest birds. *The Auk* **101:**672- 84.

Rodewald A D (2003) Decline of oak forests and implications for forest wildlife conservation. *Nat Areas J* **23:**368-71.

Rodewald A D and Abrams M D (2002) Floristics and avian community structure: implications for regional changes in eastern forest composition. *Forest Sci* **48:**267.

Rodewald P G and Brittingham M C (2007) Stopover habitat use by spring migrant landbirds: the roles of habitat structure, leaf development, and food availability. *Auk* **124:**1063-74.

Rodríguez-Estrella R (2007) Land use changes affect distributional patterns of desert birds in the Baja California peninsula, Mexico. *Divers Distrib* **13:**877-89.

Rolstad J (1991) Consequences of forest fragmentation for the dynamics of bird populations: conceptual issues and the evidence. *Biol J Linnean Soc* **42:**149-63.

Rotenberry J T (1985) The role of habitat in avian community composition: physiognomy or floristics. *Oecologia* (Berlin) **67:**213-17.

Rumble M A (1992) Roosting habitat of Merriam's Turkeys in the Black Hills, South Dakota. *J Wildl Manag* **56**:750-59.

Sabo S R (1980) Niche and habitat relations in subal pine bird communities of the White Mountains of New Hampshire. *Ecol Monogr* **50**:241-59.

Sahni K C (1998) The Book of Indian Trees. Oxford University Press, New Delhi.

Saloni G (2010) *Evaluation of different breeding provisions for their acceptance by birds.* M.Sc. thesis, Punjab Agricultural University, Ludhiana, India.

Sandhu S K (1993) *Ecological studies on the association of birds with trees with special reference to nest-site selection*. Ph.D. dissertation. Punjab Agricultural University, Ludhiana, India

Sangha H S and Naoroji R (2004) Nidification of the Common Raven *Corvus corax* in the Thar Desert. *J Bombay Nat Hist Soc* **101:**321-23.

Santhanakrishnan R, Ali A M S and Anbarasan U (2010) Diet variations of the Barn Owl *Tyto alba* (Scopoli, 1769) in Madurai District, Tamil Nadu, Southern India. *Podoces* **5:**95-103.

Savard J P L, Clergeau P and Mennechez G. (2000) Biodiversity concepts and urban ecosystems. *Landsc Urban Plan* **48**:131-42.

Sax D F (2002) Equal diversity in disparate species assemblages: a comparison of native and exotic woodlands in California. *Global Ecol Biogeogr* **11:**49–57.

Saxena V L, Pandey E, Agarwal S and Saxena A K (2008) Execution of Breeding and Nidification Behaviour in Pigeon (*Columba livia*) and Dove (*Streptopelia chinensis*). *Asian J Exp Sci* **22(3):**405-10.

Schaub M, Jenni L and Bairlein F (2008) Fuel stores, fuel accumulation, and the decision to depart from a migration stopover site. *Behav Ecol* **19:**657-66.

Schlossberg S and King D I (2008) Are shrubland birds edge specialists? *Ecol Appl* **18:**1325-30.

Schmiegelow F K A and Monkkonen M (2009) Habitat Loss and Fragmentation in Dynamic Landscapes: Avian Perspectives From the Boreal. *Ecol Appl* **12:**375-89.

Sedgwick J A and Knope F L (1992) Cavity turnover and equilibrium cavity density in a cotton-wood bottomland. *J Wildl Manag* **56:**477-84.

Sekercioglu C H (2006) Foreword. In: Josep del Hoyo, Andrew Elliott & David Christie (ed) *Handbook of the Birds of the World: Old World Flycatchers to Old World Warblers*. Vol 2, pp. 48. Lynx Edicions, Barcelona.

Sengupta S, Mondal M, and Basu P (2014) Bird species assemblages across a rural urban gradient around Kolkata, India. *Urban Ecosyst* **17:**585-96.

Shochat E, Abramsky Z, Pinshow P and Whitehouse M E A (2002) Density-dependent habitat selection in migratory passerines during stopover: what causes the deviation from IFD? *Evol Ecol* **16:**469-88.

Shochat E, Lerman S B, Katti M and Lewis D B (2004) Linking optimal Foraging behaviour to bird community structure in an Urban-Desert Landscape: Field Experiments with artificial food patches. *Am Nat* **164:**232-43.

Sibley D A (2001) *The Sibley Guide to Bird Life and Behavior*. Pp 225-90. Alfred A Knopf Inc, New York.

Sinu P A, Shivanna K R and Kuriakose G (2012) Frugivorous bird diversity and their post-feeding behaviour in fruiting Syzygium cumini (Myrtaceae) in fragmented forests of central Western Ghats, India. *Curr Sci* **103(10):**1146-48.

Smith Dodsworth J C (1991) *New Zealand native shrubs and climbers.* Pp 1-104. David Bateman Publications, Auckland.

Smith G, Gittings T, Wilson M, French L, Oxbrough A, O'Donoghue S, O'Halloran J, Kelly D, Mitchell F, Kelly T, Iremonger S, McKee A M and Giller P (2008) Identifying practical indicators of biodiversity for stand-level management of plantation forests. *Biodivers Conserv* **17:**991-1015.

Smith R J, Moore F R and May C A (2007) Stopover habitat along the shoreline of northern Lake Huron, Michigan: emergent aquatic insects as a food resource for spring migrating landbirds. *Auk* **124:**107-21.

Spellerberg I F and Fedor P J (2003) A tribute to Claude Shannon (1916-2001) and a plea for more rigorous use of species richness, species diversity and the "Shonnon- Wiener" index. *Glob Ecol Biogeo* **12:**177-79.

Stevenson P R (2001) The relationship between fruit production and primate abundance in neotropical communities. *Biol J Linn Soc* **72:**161-78.

Storch D, Konvicka M, Benes J, Martinkova J and Gaston J K (2003) Distribution patterns in butterflies and birds of the Czech Republic: separating effects of habitat and geographical position. *J Biogeogr* **30:**1195-1205.

Strong A M and Sherry T W (2000) Habitat-specific affects of food abundance on the condition of Ovenbirds wintering in Jamaica. *J Anim Ecol* **69:**883-95.

Styring A R and Ickes K (2001) Woodpecker abundance in a logged (40 years ago) vs. unlogged lowland dipterocarp forest in Peninsular Malaysia. *J Trop Ecol* **17:**261-68.

Subramanian K S and John M C (2001) Roosting and nesting habits of free ranging Indian Peafowl (*Pavo cristatus*) in southern Tamil Nadu. *Zoos' Print J* **16:**537-38.

Sultana A, Hussain M S and Khan J A (2007) Bird communities of the proposed Naina and Pindari Willife Sanctuaries in the Kumaon Himalaya, Uttarakhand, India. *J Bombay Nat His Soc* **104**:19-29.

Tallamy D W and Shropshire K J (2009) Ranking Lepidopteran use of native versus introduced plants. *Conserv Biol* **23:**941-47.

Tanveer A, Chaudhry MA and Aleem A (2002) Avian fauna of Punjab University, Lahore. *Punjab Univ J* **17:**35-51.

Tellerı´a J L, Pe´rez-Tris J, Ramı´rez A, Ferna´ ndez-Juricic E and Carbonell R (2001) Distribution of Robins (Erithacus rubecula) in wintering grounds: effects of conspecific density, migratory status and age. *Ardea* **89:**363-73.

Telleria J L and Galarza A (1990) Avifauna y paisaje en el Norte de Espana :effect de las repoblaciones con arboles exoticos. *Ardea* **37:**229-45.

Terborgh J, Robinson S K, Parker T A, Munn C A and Pierpont N (1990) Structure and organization of an Amazonian forest bird community. *Ecol Monographs* **60:**213-38.

Tewes J, Brose U, Grimm V, Tielborger K, Wichmann M C, Schwagen M and Jeltsch F (2004). Animal species diversity driven by habitat heterogeneity/diversity: the importance of keystone structures. *J Biogeogr* **31:**79-92

Thakur M L and Narang S K (2012) Population status and habitat-use pattern of Indian white-backed vulture (*Gyps bengalensis*) in Himachal Pradesh, India. *J Ecol Nat Environ* **4:** 173-80.

Thakur M L and Paliwal R (2012) Avian diversity of Chandigarh (UT). *Int J Adv Biol Res* **2:** 103-14.

Toland B (1990) Use of power poles for nesting by Red-Tailed Hawks in SC Florida. *Can Field Nat* **18:**52-55.

Toor H S, Kaur H and Dhindsa, M S (1986) Community structures and feeding ecology of birds at a grain store in Punjab, India. *Tropical Sci* **26:**233-47.

Trango L A, Valdez R, Clemente F and Mendoza G (2001) Roost site characteristics of Mexican Spotted Owls in Sierra Fria, Agua Scalientes, mexico. *J Raptor Res* **35:**165-68.

Trivedi P (1993) *Habitat selection by Indian peafowl in Gir Forest.* M.Sc.thesis, Saurashtra University (Unpublished) pp. 36.

Trivedi P and Johansingh A J T (1996) Roost selection by Indian Peafowl *Pavo cristatus* in Gir forest India. *J Bombay Nat Hist Soc* **93:**25-29.

Truslow F K (1979) *The Nesting Season: The Bird photograph. A study book*. Pp 1-136. The Viking Press, New York.

Tscharntke T, Sekercioglu C H, Dietsch T V, Sodhi N S, Hoehn P and Tylianakis J M (2008) Landscape constraints on functional diversity of birds and insects in tropical agroecosystems. *Ecology* **89:**44-51.

Virkkala R (1989) Short term fluctuations of bird communities and populations in virgin and managed forest in Northern Finland. *Ann Zool Fenn* **26:**277-85.

Ward J P, Gutierrez R J and Noon B R (1998) Habitat selection by Northern Spotted Owls: The consequences of prey selection and distribution. *Condor* **100:**79-92.

Westphal C I, Dewenter S and Tscharntke T (2006) Bumblebees experience landscapes at different spatial scales: possible implications for coexistence. *Oecologia* **149:**289-300.

Whittingham M J and Evans K L (2004) The effects of habitat structure on predation risk of birds in agricultural landscapes. *Ibis* **146(2):**210-20.

Wiktander U, Olsson O and Nilsson SG (2001) Seasonal variation in home-range size, and habitat area requirement of the lesser spotted woodpecker (Dendrocopos minor) in southern Sweden. *Biol Conserv* **100:**387-95.

Wilson M V, Gittings T, Kelly T C and O'Halloran J (2010) The importance of non-crop vegetation for bird diversity in Sitka Spruce plantations in Ireland. *Bird Study* **57:** 116-20.

Winkler D (2005) Ecological succession of breeding bird communities in Deciduous and Coniferous forests in the Sopron, Hungury. *Acta Silv Lign Hung* **1:**49-58.

Yoganand K and Davidar P (2000) Habitat preferences and distributional status of some forest birds in Andaman Islands. *J Bombay Nat Hist Soc* **97:**375-80.

Yong W, Finch D M, Moore F R and Kelly J F (1998) Stopover ecology and habitat use of migratory Wilson's Warblers. *Auk* **7:**829-42.

Young K E, Valdez R, Zwank P J and Gould W R (1998) Density and roost site characteristics of spotted owls in the Sierra Madre Occidental, Chihuahua, Mexico. *Condor* **100:**732-36.

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