PROJECT REPORT ON

SUBTROPICAL BROAD-LEAVED FORESTS AS THE FOREMOST DYNAMIC AND COMPLEX HABITATS FOR A WIDE RANGE OF BIRD SPECIES

Principal Investigator:	Assoc. Prof. Dr. Muhammad Nawaz Rajpar
Co- Principal Investigator:	Shahb Ali Khan
Affiliation:	Shaheed Benazir Bhutto University Sheringal Dir Upper, Khyber Pakhtunkhwa
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Summary

Broad-leaved subtropical forests are the most productive, diversified, and complex ecosystems on the planet. Unfortunately, forests are currently under severe threat from anthropogenic activities, such as; deforestation, housing settlements, and agricultural expansion. In response to these severe effects, the present study was conducted to explore the current conservation status and population structure of a wide range of bird species inhabiting different subtropical broad-leaved urban forests of Pakistan. In total, 2879 individuals comprising 53 species and 28 families were detected between December 2017 and November 2018 as revealed through the distance sampling line transect method. The habitat selection among bird species varied according to vegetation structure and composition, food resources, adjoining habitats, and human settlements. According to IUCN Red List data, one species was deemed vulnerable out of 53 bird species, while the remaining 52 species were ranked as of least concern. The findings of the density analysis revealed that bird density varied between six subtropical broad-leaved forests. Palamar (3.954 ± 0.221 birds/ha) and Kityari (3.138 ± 0.162 birds/ha) were densely populated, whereas Kamal Khan (1.102 ± 0.178 birds/ha) was of the least concern. Likewise, the diversity analysis showed that Kamal Khan was a more diverse habitat (Shannon–Wiener Index; H' = 3.581 ± 0.021). Shahabad was richer (Margalef Richness Index; R1 = 8.007 ± 0.053) and Dob Ghar was evenly distributed (Pielou J Evenness Index; E = 0.940 ± 0.005) compared to other urban habitats studied. Eight foraging guilds were identified among the bird species. Insectivores were the most abundant bird species utilizing the urban dwelling habitats. Carnivores/piscivores/insectivores utilized Dob Ghar forest, while more frugivores utilized Kamal Khan and Dob Ghar. Based on the data, it was concluded that subtropical broad-leaved urban forests are dynamic, complex, and of vital significance for a diverse range of bird species.

Introduction

Broad-leaved subtropical forests are among Pakistan's most productive, diversified and complex ecosystems and vegetation is dominated by persistent and semi-persistent deciduous species. The main tree and shrub species that grow in the habitats include Indian horse chestnut (*Aesculus indica*), Indian maple (*Acer caesium*), tapering leaf maple (*Acer acuminatum*), Himalayan elm (*Ulmus wallichiana*), West Himalayan alder or sharol (*Alnus nitida*), kamala or kumkum tree (*Mallotus philippensis*), Indian willow (*Salix tetrasperma*), common fig (*Ficus carica*), chamror (*Ehretia aspera*), and sweet plum (*Sageretia theezans*). The shrubs comprised kau (*Olea ferruginea*), phulai (*Acacia modesta*), fragrant bay tree (*Persea odoratissima*), Christmas flower (*Phoebe pulcherrima*), Indian laburnum (*Cassia fistula*), phulai (*Acacia modesta*) and snatha (*Dodonaea viscosa*, *Berberis lyceum*, *Indigo fera*, *Carica spinarium*), common buckthorn (*Rhamnus pentapomica*) and mallah ber (*Zizyphus nummularia*). Grass species include aucher's grass (*Chrysopogon aucheri*), elephant grass (*Pennisetum purpureum*), tanglehead grass (*Heteropogon contortus*), sabai grass (*Eulaliopsis binate*), buffelgrass (*Cenchrus ciliaris*), khabbal (*Cynodon dactylus*), and other turf grasses.

The vegetation diversity and cover percentage are crucial variables used to predict the relative abundance of avian species and richness. Complex floristic compositions harbor a wide array of avian species. Birds are a vital indicator of the ecosystem of an urban forest. Avian community parameters are impacted by the extent of spatiotemporal dissemination of floristic structure, microclimate conditions and food resources. Birds prefer sites that fulfill their needs, such as water, cover, and breeding shelter. Birds are food and habitat specialists motivated by richness and diversity; they often select urban forest habitats to satisfy their needs.

Birds are an integral component of broad-leaved subtropical forests and play important roles in protecting and managing the pest populations that can destroy seeds, leaves, and roots of trees, shrubs, and grasses. They spread seeds from one region to another through droppings, which may assist in regeneration. Birds are also the best bio-indicators of the health of a subtropical broad-leaved forest ecosystem (two–thirds of bird species occupy forested habitats). Their presence in a broad-leaved forest ecosystem indicates productivity and habitat. Unfortunately, broad-leaved subtropical forests are facing overwhelming threats due to the human interventions such as housing settlements and expansion of agriculture that cause habitat loss and degradation. Habitat loss and degradation reduces the suitability and productivity of ecosystems, resulting in declines in the populations of many species of forest birds. Some species become vulnerable, endangered, threatened, critically endangered, and even vanish due to illegal hunting for bushmeat.

For conservation activities, the determination of status of bird species and population structure (relative abundance, indices of diversity, and density) is critical importance. The objective of the project is to determine the existing population structure of a wide range of bird species inhabiting subtropical forests to ensure that bird conservation increases the population and minimizes the potential threats. The second objective is to determine the urban forest that harbors the highest bird diversity and density. The third objective is to determine the species that are endangered or threatened and should be protected on a priority basis.

Methodology

The present research work was conducted in subtropical broad-leaved forests, such as; Dob Ghar, Kamal Khan, Kityari, Palamar, Seya Sar, and Shahabad, occurring 1600–3300 feet elevation above mean sea level in the inner foothills of the Himalayas in Pakistan (Figure 1).

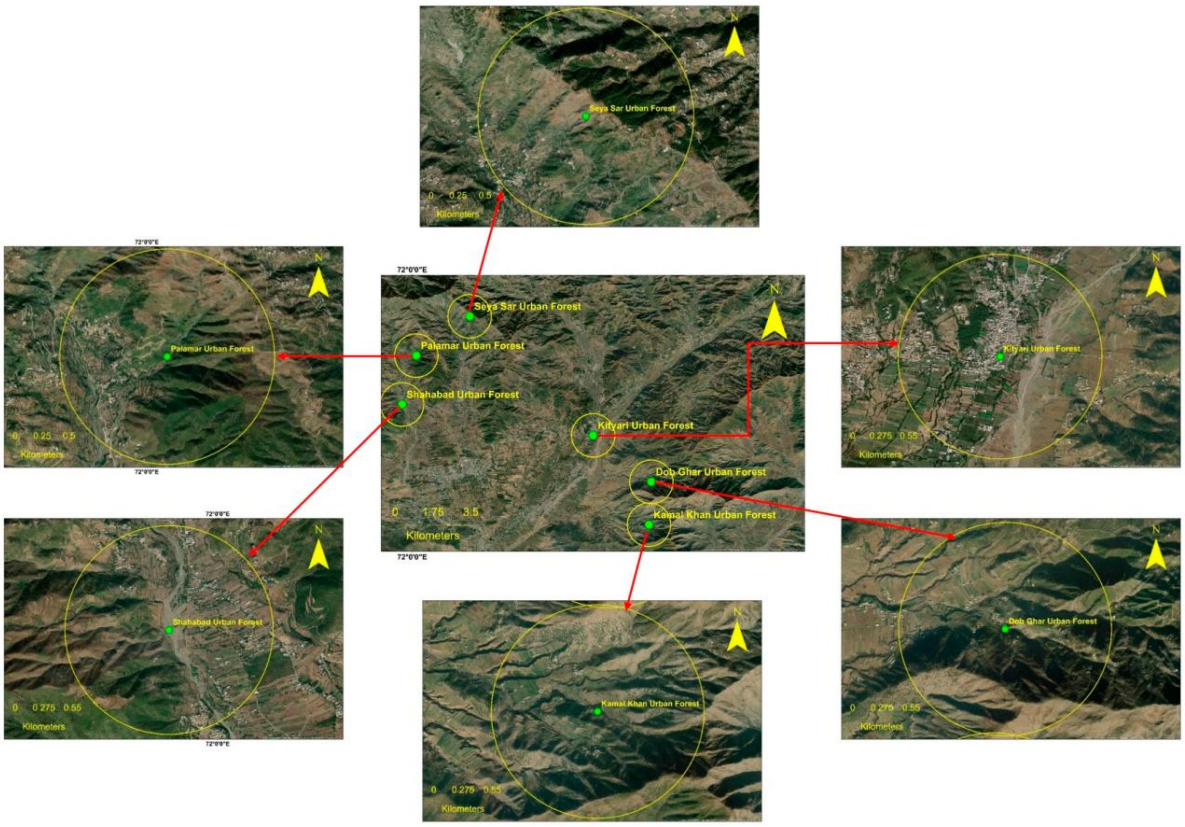


Figure 1. Location map of the study areas.

These forests contain evergreen trees and shrubs varying in floristic composition, ranging from dense to scattered canopy and groups in well-protected sites. The vegetation encompasses the trees such as Indian horse–chestnut (*Aesculus indica*), Indian maple (*Acer caesium*), tapering leaf maple (*Acer acuminatum*), Himalayan elm (*Ulmus wallichiana*), West Himalayan alder or sharol (*Alnus nitida*), kamala or kumkum tree (*Mallotus philippensis*), Indian willow (*Salix tetrasperma*), common fig (*Ficus carica*), chamror (*Ehretia aspera*), and sweet plum (*Sageretia theezans*). The shrubs comprised kau (*Olea ferruginea*), phulai (*Acacia modesta*), fragrant bay tree (*Persea odoratissima*), Christmas flower (*Phoebe pulcherrima*), Indian laburnum (*Cassia fistula*), phulai (*Acacia modesta*) and snatha (*Dodonaea viscosa*, *Berberis lyceum*, *Indigo fera*, *Carica spinarium*), common buckthorn (*Rhamnus pentapomica*) and mallah ber (*Zizyphus nummularia*). Grass species include aucher's grass (*Chrysopogon aucheri*), elephant grass (*Pennisetum purpureum*), tanglehead grass (*Heteropogon contortus*), sabai grass (*Eulaliopsis binate*), buffelgrass (*Cenchrus ciliaris*), khabbal (*Cynodon dactylus*), and other turfgrasses. The vegetation diversity forms a multi-layered canopy comprising trees, shrubs, and grasses. Depending on rainfall pattern, aspect, topography, elevation and anthropogenic variables such as unregulated grazing, selection of heavy fuelwood, and land use pattern, the composition of vegetation species varies

from site to site. Each forest represents a distinct habitat type supporting different avian species. The characteristics of each habitat are given in Table 1.

Dob Ghar Subtropical Broadleaf Forest	34^0 43" 36' N	72^0 05" 56' E
Kamal Khan Subtropical Broadleaf Forests	34^0 42" 32' N	72^0 05" 53' E
Kityari Subtropical Broadleaf Forest	34^0 44" 46' N	72^0 04" 29' E
Palamar Subtropical Broadleaf Forest	34^0 46" 46' N	72^0 0" 04' E
Seya Sar Subtropical Broadleaf Forest	34^0 47" 44' N	72^0 01" 26' E
Shahabad Subtropical Broadleaf Forests	34^0 45" 31' N	71^0 59" 47' E

Bird Survey

In total, 120 transect lines were established randomly over a hilly topography (20 transect lines in each habitat with a length of 2 km) to assess bird populations in each habitat. Birds were detected early in the morning from 7:30 a.m. to 11:00 a.m. from December 2017 to November 2018. All the birds seen and heard were listed in each survey. By visual assessment, the perpendicular distance between the birds and the transect line was recorded. Opportunistic observations of airborne birds of unknown origin were also reported but were not included in the analysis.

Data Analysis

Relative Species Abundance

The relative abundance of bird species in each urban forest was assessed using the following equation:

Relative species abundance (%) = $Isi/\sum Nsi \times 100$

Where Isi = Total number of bird individual species and $\sum Nsi$ = Total number of bird species

Comparison of Bird Relative Abundance among Six Coniferous Forests

Bird relative abundance was compared using one-way analysis of variance (ANOVA) and Tukey's honestly significant difference (HSD) test (Analytical Software, version 8.1) by McGraw–Hill (located in New York City, NY, USA).

Bird Density

Ascertaining the exact population size is imperative in obtaining the current pop-ulation status of different bird species in a dwelling habitat. The bird population was determined through the DISTANCE Software (Version 7.1).

Diversity Indices

Examining the distinguishing features in avian assemblages and diversity is a critical step in depicting of

subtropical broad-leaved urban forest habitats. Diversity indices such as species diversity, species richness, and regularity were identified using the Community Analysis Package (CAP, version 4.0,). In this study, the avian Shannon Species Diversity Index

Comparison of Foraging Guild Structure in Six Subtropical Broad-Leaved Urban Forest Habitats

The structure of the feeding guild is an assemblage of bird species that consume the same food resources using different techniques. Bird species were grouped into eight guilds based on dietary behavior, food selection, and territory preferences.

Results

Bird Species Composition and Relative Abundance

In total, 2879 bird individuals representing 53 species from 28 families were detected in 6 subtropical urban broad-leaved forest habitats. These habitats were Shahabad, (49 species; 594 birds), Seya Sar (45 species; 391 individuals), Palamar (50 species; 497 detections), Kamal Khan (47 species; 437 individuals), Dob Ghar (51 species; 515 individuals) and Kityari (46 species; 445 individuals) (Table 2). Out of 53 bird species, 1 species was vulnerable (VU) whereas the other 52 species were ranked of least concern (LC) according to the IUCN Red List. The relative abundance of avian species may vary from habitat to habitat. For example; common myna in Dob Ghar (35 detections), Kamal Khan (30 detections) and Kityari (27 detections); chakor in Kityari (35 detections); and house crow in Shahabad (80 detections) were the most common bird species in six urban forests. In contrast, shikra and speckled wood pigeon (Shahabad), shikra, yellow-footed green pigeon, and Indian roller (Seya Sar); blue whistling thrush, white-throated kingfisher and green bee-eater (Palamar); shikra, Indian roller and Asian koel (Kamal Khan); shikra (Dob Ghar); and shikra and black-shouldered kite (Kityari) were the rarest bird species, each recorded once (Table 2). The abundance-ranking curve showed the distribution patterns of relative abundance of bird species in six subtropical urban broad-leaved forest habitats.

Family	Scientific Name	Common Name	Dob Ghar	Shahabad	Kityari	Seya Sar	Kamal Khan	Palamar	Dob Ghar
Sturnidae	*Acridotheres tristis*	Common myna	1.216	1.042	0.938	1.111	0.729	1.389	LC
Corvidae	*Corvus splendens*	House crow	1.042	0.347	0.278	0.556	0.175	2.779	LC
Fringillidae	*Carpodacus erythrinus*	Common rosefinch	1.042	1.216	0.521	0.695	0.347	1.042	LC
Passeridae	*Passer montanus*	Eurasian tree sparrow	1.042	0.799	0.590	0.452	0.347	1.111	LC
Phasianidae	*Alectoris chakur*	Chakur	0.868	0.695	1.216	0.243	0.417	0	LC
Passeridae	*Passer domesticus*	House sparrow	0.729	0.347	0.347	1.042	0.521	1.737	LC
Sturnidae	*Sturnus vulgaris*	Common starling	0.729	0.417	0.347	0.278	0.625	0.417	LC
Hirundinidae	*Hirundo rustica*	Common swallow	0.695	0.347	0.278	1.042	0.695	0.799	LC
Leiothrichidae	*Turdoides caudate*	Common babbler	0.695	0.347	0.695	0.868	0.521	0.868	LC

Dicruridae	*Dicrurus macrocercus*	Black drongo	0.625	0.417	0.521	0.695	0.347	0.695	LC
Leiothrichidae	*Trochalopteron lineatum*	Streaked laughing thrush	0.625	0.208	0.521	0.417	0.347	0.521	LC
Phasianidae	*Coturnix coturnix*	Common quail	0.521	0.347	0.521	0.695	0.695	0.417	LC
Monarchidae	*Terpsiphone paradise*	Indian paradise	0.521	0.695	0.521	0.695	0.347	0.868	LC
Leiothrichidae	*Trochalopteron lineatum*	Streaked laughing thrush	0.625	0.208	0.521	0.417	0.347	0.521	LC
Phasianidae	*Coturnix coturnix*	Common quail	0.521	0.347	0.521	0.695	0.695	0.417	LC
Paridae	*Parus cinereus*	flycatcher Cinereous tit	0.521	0.695	0.625	0.417	0.452	0.695	LC
Pycnonotidae	*Pycnonotus cafer*	Red–vented bulbul	0.521	0.695	0.625	0.521	0.347	0.521	LC
Sturnidae	*Sturnus pagodarum*	Brahminy starling	0.521	0.069	0.278	0.208	0.139	0.347	LC
Turdidae	*Turdus atrogularis*	Black–throated thrush	0.521	0.695	0.868	1.042	0.695	0.139	LC
Emberizidae	*Emberiza cia*	Rock bunting	0.452	0.695	0.278	0.139	0.347	0.278	LC
Corvidae	*Corvus macrorhynchos*	Large–billed crow	0.347	0.521	0.417	0.175	0.347	0.139	LC
Laniidae	*Lanius tephronotus*	Grey–backed shrike	0.347	0.313	0.243	0.278	0.347	0.695	LC
Phylloscopidae	*Phylloscopus collybita*	Common chiffchaff	0.347	0.243	0.486	0.625	0.521	0.417	LC
Pycnonotidae	*Pycnonotus leucogenys*	Himalayan bulbul	0.347	0.278	0.347	0.451	0.313	0.208	LC
Columbidae	*Streptopelia orientalis*	Oriental turtle dove	0.313	0.175	0.278	0.243	0.175	0.278	LC
Oriolidae	*Oriolus oriolus*	Golden oriole	0.313	0.347	0.417	0.486	0.452	0.660	LC
Alaudidae	*Galerida cristata*	Crested lark	0.278	0.139	0.069	0.104	0.069	0.139	LC
Columbidae	*Streptopelia turtur*	European turtle dove	0.243	0.139	0.104	0.175	0.243	0.139	VU
Columbidae	*Streptopelia chinensis*	Spotted dove	0.208	0.417	0.347	0.175	0.069	0.139	LC
Columbidae	*Columba livia*	Rock pigeon	0.175	0.347	0.243	0.139	0.069	0.069	LC
Laniidae	*Lanius vittatus*	Bay–backed shrike	0.175	0.139	0.069	0.139	0.175	0.347	LC
Motacillidae	*Motacilla alba*	White wagtail	0.175	0.139	0.556	0.347	0.139	0.347	LC
Falconidae	*Falco tinnunculus*	Common kestrel	0.139	0.139	0.175	0.104	0.069	0.069	LC
Phasianidae	*Francolinus francolinus*	Black francolin	0.139	0.104	0.278	0.175	0.208	0.069	LC
Muscicapidae	*Saxicola caprata*	Pied bushchat	0.139	0.175	0.139	0.208	0.278	0.208	LC
Phylloscopidae	*Phylloscopus senegalensis*	Lemon–rumped warbler	0.278	0.104	0.175	0.452	0.347	LC	0.278
Corvidae	*Dendrocitta vagabunda*	Rufous treepie	0.104	0.069	0.069	0.139	0.069	0.139	LC
Motacillidae	*Motacilla cinerea*	Grey wagtail	0.104	0.139	0.208	0.139	0.069	0.208	LC

Accipitridae	*Accipiter virgatus*	Besra	0.069	0.035	0.104	0.069	0	0.035	LC
Upupidae	*Upupa epops*	Common hoopoe	0.069	0	0.104	0	0.069	0.069	LC
Columbidae	*Streptopelia sp.*	Laughing dove	0.069	0.243	0.104	0.069	0.139	0.139	LC
Columbidae	*Treron phoenicoptera*	Yellow-footed green	0.069	0.035	0	0	0	0.069	LC
Sturnidae	*Acridotheres ginginianus*	Bank myna	0.069	0	0	0.208	0	0	LC
Strigidae	*Glaucidium brodiei*	Collard owl	0.069	0.069	0	0.313	0.139	0.139	LC
Accipitridae	*Accipiter badius*	Shikra	0.035	0.035	0.069	0.035	0.035	0	LC
Coraciidae	*Coracias benghalensis*	Indian roller	0.069	0.035	0	0.035	0	0.069	LC
Cuculidae	*Eudynamys scolopacea*	Asian koel	0.069	0	0	0.035	0	0.104	LC
Muscicapidae	*Myophonus caeruleus*	Blue whistling thrush	0.069	0.139	0.069	0.139	0.139	0.104	LC
Muscicapidae	*Copsychus saularisi*	Oriental magpie robin	0.069	0.069	0	0.069	0	0.069	LC
Phylloscopidae	*Phylloscopus*	Greenish warbler	0.069	0.175	0.243	0.347	0.243	0.278	LC
Coraciidae	*Coracias benghalensis*	Indian roller	0.069	0.035	0	0.035	0	0.069	LC
Pycnonotidae	*Pycnonotus leucotis*	White–eared bulbul	0.069	0.104	0.139	0.347	0.521	0.139	LC
Columbidae	*Columba hodgsonii*	Speckled wood pigeon	0.035	0	0.035	0	0	0.069	LC

Comparison of Foraging Guilds of Avian Species in Six Subtropical Broad-Leaved Urban Forest Habitat

The results of foraging guilds revealed that feeding guilds of avian species vary from habitat to habitat. Insectivores, comprising the greenish warbler, lemon–rumped warbler, common chiffchaff, cinereous tit, oriental magpie robin, pied bush chat, grey wagtail, white wagtail, Indian paradise flycatcher, common babbler, bay–backed shrike, grey-backed shrike, common swallow, rock bunting, black drongo, crested lark, green bee-eater and Indian roller, were the most abundant guild in all habitats. Omnivores (5.592%) heavily occupied the Kityari urban forest habitat. In contrast, carnivores/piscivores/insectivores (white-throated kingfisher) avoided Dob Ghar and frugivores (speckled wood pigeon and yellow-footed green pigeon) avoided Kamal Khan and Dob Ghar urban forests (Table 4).

Guild	Shahabad	Seya Sar	Palamar	Kamal Khan	Dob Ghar	Kityari
Carnivore	0.313%	0.278%	0.347%	0.625%	0.313%	0.278%
Insectivore	5.488%	5.036%	5.175%	6.391%	5.141%	7.398%
Carnivore/Piscivore/Insectivore	0.069%	0.069%	0.035%	0.069%	0	0.069%

Granivore	1.007%	1.320%	1.077%	0.799%	0.695%	0.764%
Frugivore	0.104%	0.035%	0.035%	0	0	0.139%
Omnivore	3.890%	3.196%	2.223%	2.918%	1.667%	5.592%
Frugivore/Insectivore	3.717%	2.952%	3.612%	3.856%	3.578%	3.057%
Granivore/Insectivore	3.300%	2.292%	2.952%	2.605%	2.188%	3.334%
Sub-Total	515	437	445	497	391	594
Grand Total			2879			

Discussions

A comparative evaluation of the avian state of conservation and community parameters of bird species inhabiting various subtropical urban forests demonstrates habitat–level ecosystem health. The findings of state conservation and population structure are paramount in conservation activities because they explain the driving forces that influence population variability specifically or by implication. Birds are bioindicators of urban forest health and productivity. Detailed information on avian community parameters helps to clarify the key driving variables that play important roles in the determining the home range and habitats, and the impact of human activity on avian diversity and habitat alteration Determining the state of conservation and population structure of bird species inhabiting subtropical urban forests provides a solid foundation for better understanding ecological trends and processes.

This comparative investigation provides useful data on various aspects of bird assemblages and their dwelling habitats, and how they could be managed on a sustainable basis and improve biodiversity conservation. This study, through an intra-specific comparison of bird species among six broad-leaved urban forests, demonstrated that 51 species pre-ferred the Dob Ghar, 45 preferred Kityari, 46 preferred Kamal Khan, 50 preferred Palamar, 44 preferred Siya Sar and 49 preferred Shahabad. Previously, it has been found that species abundance tends to increase with landscape diversity and decrease with low vegetation coverage that might provide scarce food resources. This premise is in line with our results presented in Figure 4. In addition, land-use patterns adjoining the urban forests influence food resources, predation, and competition between avian species present in urban forest domains. Structural modifications in vegetation structure alter habitat suitability, foliage, food, and ground vegetation. These factors alter the home range and mobility of avian species.

In addition, the findings of this study illustrate that urban forests bolster a distinctive range of bird communities, which may vary according to floristic composition, food resources, and extent of the impacts of human activity. For example, Palamar and Kityari dynamic subtropical urban broad-leaved habitats harbored a higher avian density than other urban territories. In addition, vegetation structure, especially foliage diversity, vegetation cover percentage, canopy cover, and food assortment, were the preeminent variables that determine higher bird diversity and density in urban forests (Figure 4). Birds are habitat specialists, generalists, and resource users that take advantage of opportunities. In comparison, the less vegetated urban forest habitats favored only a few bird species as clear from the

low value of correlation coefficient in Figure 4.

Furthermore, the findings of the Community Analysis Package revealed that in six subtropical urban forests, the diversity indices and population of bird species varied. This might be due to the fact that the range and selection of habitats among bird species varied depending on the floristic composition, the availability of food resources (e.g., insects, fruits, grains, amphibians, reptiles and small mammals), adjacent habitats (e.g., agricultural and orchard fields offering suitable foraging and breeding sites) and human activity. This premise is evident from the results presented in Figure 4. It has been revealed that complex vegetation creates a pool of competence that attracts a diverse range of bird species, reducing competition and helping other species through the creation of niches. It may also be due to the fact that these bird species belong to various foraging guilds in heterogeneous environments where they forage and eat a wide range of food items. Thrushes, for instance, frequently incline towards the thick scrub stands, forest edges, moist places, and grassy beds to bolster on invertebrates, such as caterpillars, ants, wasps, grasshoppers, beetles, and wing flies.

Further, frugivore/insectivore birds, such as starlings, orioles, thrushes, and bulbuls, were also measured in sufficient numbers. The reason behind the large numbers of fruit-and insect-eating birds detected could be the availability of fruit and insects that may be attributed to birds utilizing the urban forest. This might be because these urban forests are complex habitats rich in floristic composition, diverse topography and humid weather conditions that harbor a wide array of invertebrates. Heterogeneity within the landscape, especially variation in topography (slope, aspect, and position), connectivity and vegetation complexity, are the major attributes that make an urban forest more attractive to avian species. Moreover, the urban forests are surrounded by agricultural fields and orchards that bear flowers and fleshy fruits that attract a wide variety of insect species, which are the staple diet of frugivore/insectivore birds. The insect-eating birds source insects from agriculture fields and fruit-eating birds consume the fleshy fruits of adjacent habitats. This shows that birds are habitat specialists; they often prefer habitats rich in food resources that offer suitable foraging grounds, breeding sites and shelter from harsh weather and predators
.
The recording of five species of raptors, namely, shikra, besra, kites, kestrels, and owls, showed that these subtropical broad-leaved urban forests are an attractive habitat for passerine birds, reptiles (lizards and snakes), small mammals (shrews, rats, squirrels and mice). According to Bosakoski and Smith [84], raptors are area-sensitive bird species that prefer habitats with high prey density and habitat heterogeneity. These characteristics are strongly associated with wildness. For example, *Buteo jamaicensis* and *Buteo viriginianus* preferred suburban habitat and *Strix varia*, *B. lineatus*, and *Accipiter cooperii* lowland areas.

Additionally, a high number of insectivore birds such as minivets, woodpeckers, bee-eaters, flycatchers, wagtails, robins, bush chats, warblers, shrikes and treecreepers were recorded in the urban forest habitats studied. The diversity of insect-eating birds might be due to the occurrence of a wide array and large number of insects, such as flies, moths, beetles, grasshoppers, caterpillars, wasps, ants, and termites, which are their staple diet. It may also be due to the presence of trees, shrubs, and grasses

that bear flowers and fruits that that attract these birds. Shrub layers add habitat complexity to the urban forest ecosystem; they provide a variety of food, asylum from predators, and potential nesting sites. The understory vegetation increases the species diversity and richness of avian communities.

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APPENDIX

Order Accipitriformes									
Family Accipitridae									
1	*Accipiter badius*	Shikra	1	1	2	1	1	0	LC
2	*Accipiter virgatus*	Besra	2	1	3	2	0	1	LC
3	*Elanus caeruleus*	Black-shouldered kite	0	0	0	3	2	1	LC
Order Bucerotiformes									
Family Upupidae									
4	*Upupa epops*	Common hoopoe	2	0	3	0	2	2	LC
Order Columbiformes									
Family Columbidae									
5	*Streptopelia chinensis*	Spotted dove	6	12	10	5	2	4	LC
6	*Streptopelia senegalensis*	Laughing dove	2	7	3	2	4	4	LC
7	*Streptopelia turtur*	European turtle dove	7	4	3	5	7	4	VU
8	*Streptopelia orientalis*	Oriental turtle dove	9	5	8	7	5	8	LC
9	*Columba livia*	Rock pigeon	5	10	7	4	2	2	LC
10	*Columba hodgsonii*	Speckled wood pigeon	1	0	1	0	0	2	LC
11	*Treron phoenicoptera*	Yellow-footed green pigeon	2	1	0	0	0	2	LC
Order Coraciiformes									
Family Alcedinidae									
12	*Halcyon smyrnensis*	White-throated kingfisher	2	2	1	2	0	2	LC
Family Coraciidae									

13	*Coracias benghalensis*	Indian roller	2	1	0	1	0	2	LC
Family Meropidae									
14	*Merops orientalis*	Green Bee-eater	0	0	1	2	2	0	LC
Order Cuculiformes									
Family Cuculidae									
15	*Eudynamys scolopacea*	Asian koel	2	0	0	1	0	3	LC
Order Falconiformes									
Family Falconidae									
16	*Falco tinnunculus*	Common kestrel	4	4	5	3	2	2	LC
Order Galliformes									
Family Phasianidae									
17	*Alectoris chakur*	Chakur	25	20	35	7	12	0	LC
18	*Francolinus francolinus*	Black francolin	4	3	8	5	6	2	LC
19	*Coturnix coturnix*	Common quail	15	10	15	20	20	12	LC
Order Passeriformes									
Family Alaudidae									
20	*Galerida cristata*	Crested lark	8	4	2	3	2	4	LC
Family Corvidae									
21	*Dendrocitta vagabunda*	Rufous treepie	3	2	2	4	2	4	LC
22	*Corvus splendens*	House crow	30	10	8	16	5	80	LC
23	*Corvus macrorhynchos*	Large-billed crow	10	15	12	5	10	4	LC
Family Dicruridae									
24	*Dicrurus macrocercus*	Black drongo	18	12	15	20	10	20	LC
Family Emberizidae									
25	*Emberiza cia*	Rock bunting	13	20	8	4	10	8	LC
Family Fringillidae									
26	*Carpodacus erythrinus*	Common rosefinch	30	35	15	20	10	30	LC
Family Hirundinidae									
27	*Hirundo rustica*	Common swallow	20	10	8	30	20	23	LC
Family Laniidae									
28	*Lanius tephronotus*	Grey-backed shrike	10	9	7	8	10	20	LC
29	*Lanius vittatus*	Bay-backed shrike	5	4	2	4	5	10	LC

Family Leiothrichidae									
30	*Turdoides caudata*	Common babbler	20	10	20	25	15	25	LC
31	*Trochalopteron lineatum*	Streaked laughing thrush	18	6	15	12	10	15	LC
Family Monarchidae									
32	*Terpsiphone paradisi*	Indian paradise flycatcher	15	20	15	20	10	25	LC
Family Motacillidae									
33	*Motacilla alba*	White wagtail	5	4	16	10	4	10	LC
34	*Motacilla cinerea*	Grey wagtail	3	4	6	4	2	6	LC
Family Muscicapidae									
35	*Myophonus caeruleus*	Blue whistling thrush	2	4	2	4	4	3	LC
36	*Copsychus saularisi*	Oriental magpie robin	2	2	0	2	0	2	LC
37	*Saxicola caprata*	Pied bushchat	4	5	4	6	8	6	LC
Family Oriolidae									
38	*Oriolus oriolus*	Golden oriole	9	10	12	14	13	19	LC
Family Paridae									
39	*Parus cinereus*	Cinereous tit	15	20	18	12	13	20	LC
Family Passeridae									
40	*Passer montanus*	Eurasian tree sparrow	30	23	17	13	10	32	LC
41	*passer domesticus*	House sparrow	21	10	10	30	15	50	LC
Family Phylloscopidae									
42	*Phylloscopus collybita*	Common chiffchaff	10	7	14	18	15	12	LC
43	*Phylloscopus chloronotus*	Lemon-rumped warbler	4	8	3	5	13	10	LC
44	*Phylloscopus trochiloides*	Greenish warbler	2	5	7	10	7	8	LC
Family Pycnonotidae									
45	*Pycnonotus cafer*	Red-vented bulbul	15	20	18	15	10	15	LC
46	*Pycnonotus leucotis*	White-eared bulbul	2	3	4	10	15	4	LC
47	*Pycnonotus leucogenys*	Himalayan bulbul	10	8	10	12	9	6	LC
Family Sturnidae									
48	*Acridotheres tristis*	Common myna	35	30	27	32	21	40	LC
49	*Acridotheres ginginianus*	Bank myna	2	0	0	6	0	0	LC
50	*Sturnus pagodarum*	Brahminy starling	15	2	8	6	4	10	LC

51	*Sturnus vulgaris*	Common starling	21	12	10	8	18	12	LC
Family Turdidae									
52	*Turdus atrogularis*	Black-throated thrush	15	20	25	30	20	4	LC
Order Strigiformes									
Family Strigidae									
53	*Glaucidium brodiei*	Collard owl	2	2	0	9	4	4	LC
Sub-Total			**515**	**437**	**445**	**497**	**391**	**594**	
Grand Total			**2879**						

	Scientific Name	Common Name	Density (birds/ha)/CI(*n* = total bird individuals detections)					
			Name of the Habitat					
			Dob Ghar	Shahabad	Kityari	Seya Sar	Kamal Khan	Palamar
Family Accipitridae								
1	*Elanus caeruleus*	Black-shouldered kite	(*n* = 2)	0	(*n* = 1)	0	(*n* = 3)	0
2	*Accipiter virgatus*	Besra	0	(*n* = 2)	(*n* = 1)	(*n* = 1)	0	(*n* = 3)
3	*Accipiter badius*	Shikra	(*n* = 1)	(*n* = 1)	0	(*n* = 1)	(*n* = 1)	(*n* = 2)
Family Alaudidae								
4	*Galerida cristata*	Crested lark	(*n* = 2)	(*n* = 8)	(*n* = 4)	(*n* = 4)	(*n* = 3)	(*n* = 2)
Family Alcedinidae								
5	*Halcyon smyrnensis*	White-throated kingfisher	0	(*n* = 2)	(*n* = 2)	(*n* = 2)	(*n* = 2)	(*n* = 1)
Family Columbidae								
6	*Streptopelia turtur*	European turtle dove	(*n* = 7)	(*n* = 7)	(*n* = 4)	(*n* = 4)	(*n* = 5)	(*n* = 3)
7	*Streptopelia orientalis*	Oriental turtle dove	(*n* = 5)	(*n* = 9)	(*n* = 8)	(*n* = 5)	(*n* = 7)	(*n* = 8)
8	*Streptopelia senegalensis*	Laughing dove	(*n* = 4)	(*n* = 2)	(*n* = 4)	(*n* = 7)	(*n* = 2)	(*n* = 3)
9	*Streptopelia chinensis*	Spotted dove	(*n* = 2)	(*n* = 6)	(*n* = 4)	0.406 ± 0.114 0.022 – 0.075 (*n* = 12)	(*n* = 5)	0.578 ± 0.210 0.027 – 0.125 (*n* = 10)
10	*Columba livia*	Rock dove	(*n* = 2)	(*n* = 5)	(*n* = 2)	(*n* = 9)	(*n* = 4)	(*n* = 7)
11	*Treron phoenicoptera*	Yellow-footed green pigeon	0	(*n* = 2)	(*n* = 2)	(*n* = 1)	0	0
12	*Columba hodgsonii*	Speckled wood pigeon	0	(*n* = 1)	(*n* = 2	0	0	(*n* = 1)
Family Coraciidae								
13	*Coracias benghalensis*	Indian roller	0	(*n* = 2)	(*n* = 2)	(*n* = 1)	(*n* = 1)	0
Family Corvidae								
14	*Corvus macrorhynchos*	Large-billed crow	0.252 ± 0.101 0.103 – 0.620 (*n* = 10)	0.833 ± 0.270 0.042 – 0.166 (*n* = 10)	(*n* = 4)	0.168 ± 0.459 0.095 – 0.296 (*n* = 15)	(*n* = 5)	0.252 ± 0.975 0.105 – 0.609 (*n* = 12)
15	*Corvus splendens*	House crow	(*n* = 5)	0.303 ± 0.119 0.125 – 0.734 (*n* = 30)	0.386 ± 0.302 0.038 – 3.904 (*n* = 80)	0.241 ± 0.121 0.069 – 0.843 (*n* = 10)	0.241±0.168 0.046 – 1.275 (*n* = 16)	(*n* = 8)
16	*Dendrocitta vagabunda*	Rufous treepie	(*n* = 2)	(*n* = 3)	(*n* = 4)	(*n* = 2)	(*n* = 4)	(*n* = 2)
Family Cuculidae								
17	*Eudynamys scolopacea*	Asian koel	0	(*n* = 2)	(*n* = 3)	0	(*n* = 1)	0
Family Dicruridae								
18	*Dicrurus macrocercus*	Black drongo	0.103 ± 0.391 0.047 – 0.230 (*n* = 10)	0.166 ± 0.732 0.068 – 0.409 (*n* = 18)	0.996 ± 0.266 0.057 – 0.173 (*n* = 20)	0.151 ± 0.432 0.080 – 0.285 (*n* = 12)	0.131 ± 0.326 0.080 – 0.218 (*n* = 20)	0.136 ± 0.504 0.062 – 0.300 (*n* = 15)
Family Emberizidae								
19	*Emberiza cia*	Rock bunting	0.108 ± 0.419 0.048 – 0.249 (*n* = 10)	0.694 ± 0.210 0.036 – 0.133 (*n* = 13)	(*n* = 8)	0.127 ± 0.487 0.059 – 0.276 (*n* = 20)	(*n* = 4)	(*n* = 8)
Family Falconidae								

20	*Falco tinnunculus*	Common kestrel	(*n* = 2)	(*n* = 4)	(*n* = 2)	(*n* = 4)	(*n* = 3)	(*n* = 5)
Family Fringillidae								
21	*Carpodacus erythrinus*	Common rosefinch	0.833 ± 0.259 0.043 – 0.161 (*n* = 10)	0.617 ± 0.177 0.034 – 0.113 (*n* = 30)	0.558 ± 0.203 0.026 – 0.119 (*n* = 30)	0.574 ± 0.183 0.030 – 0.112 (*n* = 35)	0.694 ± 0.212 0.036 – 0.134 (*n* = 20)	0.254 ± 0.111 0.090 – 0.720 (*n* = 15)
Family Hirundinidae								
22	*Hirundo rustica*	Common swallow	0.108 ± 0.353 0.055 – 0.211 (*n* = 20)	0.648 ± 0.175 0.365 – 1.151 (*n* = 20)	0.228 ± 0.170 0.026 – 2.040 (*n* = 23)	0.129 ± 0.425 0.063 – 0.263 (*n* = 10)	0.196 ± 0.119 0.042 – 0.905 (*n* = 30)	(*n* = 8)
Family Laniidae								
23	*Lanius tephronotus*	Grey-backed shrike	0.103 ± 0.376 0.048 – 0.223 (*n* = 10)	0.694 ± 0.289 0.029 – 0.165 (*n* = 10)	0.133 ± 0.480 0.064 – 0.280 (*n* = 20)	0.123±0.476 0.053 – 0.287 (*n* = 10)	(*n* = 8)	(*n* = 7)
24	*Lanius vittatus*	Bay-backed shrike	(*n* = 5)	(*n* = 5)	0.771±0.259 0.037 – 0.159 (*n* = 10)	(*n* = 4)	(*n* = 4)	(*n* = 2)
Family Leiothrichidae								
25	*Turdoides caudate*	Common babbler	0.641 ± 0.231 0.030 – 0.139 (*n* = 15)	0.525 ± 0.173 0.027 – 0.103 (*n* = 20)	0.717 ± 0.186 0.042 – 0.124 (*n* = 25)	0.222 ± 0.737 0.109 – 0.455 (*n* = 10)	0.887 ± 0.249 0.050 – 0.158 (*n* = 25)	0.790 ± 0.253 0.040 – 0.156 (*n* = 20)
26	*Trochalopteron lineatum*	Streaked laughing thrush	0.205 ± 0.525 0.119 – 0.356 (*n* = 10)	0.729 ± 0.295 0.031 – 0.169 (*n* = 18)	0.101 ± 0.340 0.050 – 0.204 (*n* = 15)	(*n* = 6)	0.109 ± 0.417 0.049 – 0.246 (*n* = 12)	0.694 ± 0.249 0.033 – 0.147 (*n* = 15)
Family Meropidae								
27	*Merops orientalis*	Green bee-eater	(*n* = 2)	0	0	0	(*n* = 2)	(*n* = 1)
Family Monarchidae								
28	*Terpsiphone paradisi*	Indian paradise flycatcher	0.896 ± 0.326 0.042 – 0.192 (*n* = 10)	0.120 ± 0.365 0.064 – 0.225 (*n* = 15)	0.176 ± 0.697 0.079 – 0.394 (*n* = 25)	0.164 ± 0.558 0.082 – 0.331 (*n* = 20)	0.144 ± 0.420 0.080 – 0.262 (*n* = 20)	0.121 ± 0.445 0.057 – 0.259 (*n* = 15)
Family Motacillidae								
29	*Motacilla alba*	White wagtail	(*n* = 4)	(*n* = 5)	0.241 ± 0.152 0.041 – 1.411 (*n* = 10)	(*n* = 4)	0.378 ± 0.253 0.011 – 1.696 (*n* = 10)	0.317 ± 0.197 0.070 – 1.445 (*n* = 16)
30	*Motacilla cinerea*	Grey wagtail	(*n* = 2)	(*n* = 3)	(*n* = 6)	(*n* = 4)	(*n* = 4)	(*n* = 6)
Family Muscicapidae								
31	*Saxicola caprata*	Pied bushchat	(*n* = 8)	(*n* = 4)	(*n* = 6)	(*n* = 5)	(*n* = 6)	(*n* = 4)
32	*Myophonus caeruleus*	Blue whistling thrush	(*n* = 4)	(*n* = 2)	(*n* = 3)	(*n* = 4)	(*n* = 4)	(*n* = 2)
33	*Copsychus saularisi*	Oriental magpie robin	0	(*n* = 2)	(*n* = 2	(*n* = 2)	(*n* = 2)	0
Family Oriolidae								
34	*Oriolus oriolus*	Golden oriole	0.548 ± 0.259 0.020 – 0.148 (*n* = 13)	(*n* = 9)	0.616 ± 0.220 0.030 – 0.128 (*n* = 19)	0.450 ± 0.162 0.020 – 0.100 (*n* = 10)	0.635 ± 0.214 0.029 – 0.140 (*n* = 14)	0.612 ± 0.205 0.030 – 0.125 (*n* = 12)
Family Paridae								
35	*Parus cinereus*	Cinereous tit	0.119 ± 0.387 0.059 – 0.241 (*n* = 13)	0.694 ± 0.238 0.033 – 0.145 (*n* = 15)	0.109 ± 0.289 0.063 – 0.191 (*n* = 20)	0.926 ± 0.324 0.045 – 0.192 (*n* = 20)	0.160 ± 0.471 0.087 – 0.295 (*n* = 10)	0.757 ± 0.235 0.039 – 0.148 (*n* = 18)
Family Passeridae								

36	*Passer montanus*	Eurasian tree sparrow	0.264 ± 0.113 0.104 – 0.674 (*n* = 10)	0.168 ± 0.367 0.108 – 0.261 (*n* = 30)	0.520 ± 0.151 0.029 – 0.095 (*n* = 32)	0.716 ± 0.268 0.033 – 0.155 (*n* = 23)	0.264 ± 0.180 0.050 – 1.411 (*n* = 13)	0.100 ± 0.310 0.052 – 0.191 (*n* = 17)
37	*Passer domesticus*	House sparrow	0.138 ± 0.404 0.076 – 0.255 (*n* = 15)	0.617 ± 0.196 0.031 – 0.122 (*n* = 21)	0.119 ± 0.308 0.071 – 0.200 (*n* = 50)	0.222 ± 0.109 0.063-0.779 (*n* = 10)	0.961 ± 0.307 0.050 – 0.185 (*n* = 30)	0.241 ± 0.126 0.069 – 0.840 (*n* = 10)
Family Phasianidae								
38	*Alectoris chakur*	Chakur	0.735 ± 0.237 0.037 – 0.144 (*n* = 12)	0.162 ± 0.553 0.081 – 0.325 (*n* = 25)	0	0.109 ± 0.363 0.056 – 0.216 (*n* = 20)	(*n* = 7)	0.347 ± 0.965 0.197 – 0.614 (*n* = 35)
39	*Coturnix coturnix*	Common quail	0.696 ± 0.307 0.028 – 0.172 (*n* = 20)	0.158 ± 0.817 0.046 – 0.552 (*n* = 15)	0.129 ± 0.855 0.024 – 0.707 (*n* = 12)	0.158 ± 0.778 0.045 – 0.558 (*n* = 10)	0.263 ± 0.153 0.021 – 3.360 (*n* = 20)	0.173 ± 0.824 0.049 – 0.621 (*n* = 15)
40	*Francolinus francolinus*	Black francolin	(*n* = 6)	(*n* = 4)	(*n* = 2)	(*n* = 3)	(*n* = 5)	(*n* = 8)
Family Phylloscopidae								
41	*Phylloscopus collybita*	Common chiffchaff	0.126 ± 0.430 0.062 – 0.257 (*n* = 15)	0.757 ± 0.244 0.037 – 0.154 (*n* = 10)	0.144 ± 0.582 0.062 – 0.337 (*n* = 12)	(*n* = 7)	0.120±0.406 0.060 – 0.239 (*n* = 18)	0.108 ± 0.379 0.053 – 0.221 (*n* = 14)
42	*Phylloscopus chloronotus*	Lemon-rumped warbler	0.104 ± 0.319 0.055 – 0.199 (*n* = 13)	(*n* = 4)	0.114 ± 0.480 0.048 – 0.273 (*n* = 10)	(*n* = 8)	(*n* = 5)	(*n* = 3)
43	*Phylloscopus trochiloides*	Greenish warbler	(*n* = 7)	(*n* = 2)	(*n* = 8)	(*n* = 5)	0.126 ± 0.467 0.058 – 0.273 (*n* = 10)	(*n* = 7)
Family Pycnonotidae								
44	*Pycnonotus cafer*	Red-vented bulbul	0.747 ± 0.253 0.036 – 0.153 (*n* = 10)	0.177 ± 0.348 0.062 – 0.221 (*n* = 15)	0.756 ± 0.242 0.039 – 0.148 (*n* = 15)	0.124 ± 0.391 0.064 – 0.242 (*n* = 20)	0.129 ± 0.459 0.062 – 0.273 (*n* = 15)	0.669 ± 0.200 0.036 – 0.124 (*n* = 18)
45	*Pycnonotus leucotis*	White-eared bulbul	0.173 ± 0.636 0.081 – 0.373 (*n* = 15)	(*n* = 2)	(*n* = 4)	(*n* = 3)	0.195 ± 0.405 0.037 – 0.228 (*n* = 10)	(*n* = 4)
46	*Pycnonotus leucogenys*	Himalayan bulbul	(*n* = 9)	0.617 ± 0.202 0.030 – 0.127 (*n* = 10)	(*n* = 6)	(*n* = 8)	0.120 ± 0.391 0.061 – 0.238 (*n* = 12)	0.252 ± 0.840 0.123 – 0.518 (*n* = 10)
Family Strigidae								
47	*Glaucidium brodiei*	Collard owl	(*n* = 4)	(*n* = 2)	(*n* = 4)	(*n* = 2)	(*n* = 9)	0
Family Sturnidae								
48	*Sturnus vulgaris*	Common starling	0.666 ± 0.219 0.033 – 0.135 (*n* = 18)	0.823 ± 0.283 0.040 – 0.169 (*n* = 21)	0.666 ± 0.236 0.031 – 0.145 (*n* = 12)	0.100 ± 0.295 0.054 – 0.187 (*n* = 12)	(*n* = 8)	0.666 ± 0.231 0.031 – 0.143 (*n* = 10)
49	*Acridotheres tristis*	Common myna	0.106 ± 0.246 0.066 – 0.171 (*n* = 21)	0.733 ± 0.203 0.042 – 0.129 (*n* = 35)	0.105 ± 0.308 0.059 – 0.191 (*n* = 40)	0.101 ± 0.382 0.047 – 0.218 (*n* = 30)	0.142 ± 0.514 0.070 – 0.293 (*n* = 32)	0.868 ± 0.284 0.045 – 0.169 (*n* = 27)
50	*Sturnus pagodarum*	Brahminy starling	(*n* = 4)	0.119 ± 0.412 0.057 – 0.247 (*n* = 15)	0.264 ± 0.135 0.066 – 1.055 (*n* = 10)	(*n* = 2)	(*n* = 6)	(*n* = 8)

51	*Acridotheres ginginianus*	Bank myna	0	(*n* = 2)	0	0	(*n* = 6)	0
Family Turdidae								
52	*Turdus atrogularis*	Black-throated thrush	0.966 ± 0.329 0.048 – 0.196 (*n* = 20)	0.104 ± 0.319 0.055 – 0.197 (*n* = 15)	(*n* = 4)	0.555 ± 0.189 0.027 – 0.113 (*n* = 20)	0.115 ± 0.400 0.058 – 0.233 (*n* = 30)	0.732 ± 0.281 0.033 – 0.161 (*n* = 25)
Family Upupidae								
53	*Upupa epops*	Common hoopoe	(*n* = 2)	(*n* = 2)	(*n* = 2	0	0	(*n* = 3)