State of Conservation and Population Structure of Bird Species Inhabiting in Various Subtropical Urban Forests

M. N. Rajpar
Shaheed Benazir Bhutto University Sheringal,
M. Zakaria (mzakaria@upm.edu.my)
Universiti Putra Malaysia

Research Article

Keywords: Birds, Population, Subtropical, Broadleaved, Urban forest, Distance Sampling

Posted Date: February 15th, 2021

DOI: https://doi.org/10.21203/rs.3.rs-193142/v1

STATE OF CONSERVATION AND POPULATION STRUCTURE OF BIRD SPECIES INHABITING IN VARIOUS SUBTROPICAL URBAN FORESTS

Rajpar, M.N.[1]and Zakaria, M.[2]*

[1] Department of Forestry, Shaheed Benazir Bhutto University Sheringal Dir (Upper), Khyber Pakhtunkhwa, Pakistan; E–mail: rajparnawaz@gmail.com
[2] Department of Forest Science and Biodiversity, Faculty of Forestry and Environment, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia. E–mail: mzakaria@upm.edu.my
* Correspondence: mzakaria@upm.edu.my

Received: date; Accepted: date; Published: date

ABSTRACT:

To determine the conservation status and population structure of avian species living in various subtropical broadleaved urban forests, namely Dob Ghar, Kamal Khan, Kityari, Palamar, Seya Sar and Shahabad of Pakistan, we aimed to use the distance sampling line transect process. To avoid double counting of the same bird individual, a total of 180 counting points were set at 250 m from each other. In all, between December 2017 and November 2018, 2,879 individuals representing 53 species, 28 families and 9 orders were detected. One species was vulnerable (VU) out of 53 bird species, while the remaining 52 species were the least concerned (LC). In particular, the results of the distance analysis indicate that, in six subtropical broad-leaved forests, the bird population can vary. For eg, Palamar (0.954 ± 0.221 birds/ha) and Kityari (0.938 ± 0.162 birds/ha) were densely populated by bird species, while Kamal Khan (0.102 ± 0.178 birds/ha) was less concerm. Similarly, the CAP findings showed that bird species in Dob Ghar were more diverse (H' = 33.92 ± 1.368) and equally distributed (E = 0.9657 ± 0.004) and that the Shahabad ecosystem was rich in bird species (R_1 = 8.007 ± 0.053) compared to other habitats. In addition, the length of the twigs and topological changes in the dendrogram have shown that bird diversity may vary from habitat to habitat. The bird species were classified into eight foraging guilds. Insectivores were the most abundant bird species using all habitats in abundance. By cons, Carnivore/Piscivore/Insectivore averted to use the forest habitats Dob Ghar and Frugivore Kamal Khan and Dob Ghar. The findings of this study revealed that broad-leaved subtropical urban forests are home to a wide range of avian species. However, habitat selection among bird species varied across habitats according to vegetation structure and composition, food resources, adjoining habitats, and human settlements.

Keywords: Birds, Population, Subtropical, Broadleaved, Urban forest, Distance Sampling

Introduction: The broad-leaved subtropical forest is the most productive, diversified and complex ecosystem covering approximately 30-40% of Pakistan's forest area (FAO, 1997). In broad-leaved subtropical forests, the composition of vegetation is dominated by persistent and semi-persistent deciduous species. Main tree and shrub species growing in the habitat include: kao - *Olea ferruginea*, phulai - *Acacia modesta*, golden shower - *Cassia fistula*, jujube, royale's spike thorn - *Gymnosporia royalina,* bhaikar or beheda - *Justicia adhatoda*, kachnar - *Bauhinia variegeta,* common fig - *Ficus carica*, anar - *Punica granatum*, sanatta - *Dodonaea viscosa,* indigo - *Indigofera tinctoria*, malabar nut - *Justica adhatoda*, and bush plum - *Carissa spinarum*.

Urban forests are rich in the diversity of vegetation and food supplies that harbor the diversity of bird species for their use (Alvey 2006; Sher et al., 2010; Rajpar 2018). The composition of plant species, food diversity and resources are key factors that decide when and which bird species could be used. Birds also prefer sites that fulfill their needs, such as water, cover and breeding shelter. Birds are food and habitat specialists, i.e. Based on richness and diversity, they also select which ecosystems and food resources are available.

Birds are an integral component of broad-leaved subtropical urban forests and also play an important role in protecting them, such as managing the population of pests that can destroy the seeds, leaves, and roots of trees, shrubs, and grasses. In addition, the flowers of trees and shrubs are pollinated by avian species in order to increase the development of seeds and spread seeds from one region to another through droppings that may assist in regeneration. Birds are also the best bioindicators of the health of the subtropical broadleaf forest ecosystem (two-thirds of bird species occupy forested habitats), i.e. they demonstrate productivity and habitat suitability (Gray et al., 2007; Rajpar and Zakaria, 2011). Birds are experts in habitat and food that have occupied every conceivable habitat and niche diversity in the food chain and food web of the forest.

Unfortunately, urban forests now face overwhelming threats due to human intervention, such as continuous sprawl and development, such as housing settlements and expansion of agriculture, which may decrease habitat suitability and productivity (Lamb et al., 2005; Wright and Muller-Landau, 2006; Chazdon, 2008; Fisher, 2010; Hansen et al., 2010). Habitat loss and degradation will reduce the suitability and productivity of ecosystems, resulting in declines in the populations of many species of forest birds (DeWalt et al., 2003; Hemandez–Stefanomi et al., 2011; Pinotti et al., 2012; Vazques–Reyes et al., 2017). Some species, for instance, become vulnerable, endangered, threatened, critically endangered, and even vanish. In addition, illegal food hunting, habitat destruction due to deforestation and the introduction into primary ecosystems of invasive species are contributing to declines in bird populations.

For conservation activities, the determination of conservation status and population structure (relative abundance, indices of diversity, and density) is of critical importance. Higher priority may be paid to a specific site for conservation and management planning on the basis of this knowledge. (IUCN, 2004; Kotiaho and others, 2005; Perez-Arteaga and others, 2005). There is still insufficient comprehensive information on bird conservation status and population structure in various subtropical broad-leaved urban forests. Furthermore, to decide which vulnerable or endangered species may be given priority for protection. The aim of this study was to determine the conservation status and population structure of a wide range of bird species inhabiting different subtropical urban forests, in order to ensure that bird conservation enhances the population and minimizes potential threats. Furthermore, to classify which species that can be protected on a priority basis are endangered or threatened.

Materials and Methods

***Study Area*:** Subtropical broadleaved urban forests occur between 1600 – 3300 feet elevation above mean sea level in the inner foothills of Himalayas, with evergreen branchy trees and shrubs varying in density from dense canopy to scattered or groups in well protected sites. These forests are the the transition ecosystem between coniferous and thorn forests. Indian horse–chestnut – *Aesculus indica*, Himalayan elm – *Ulmus wallichiana,* kikar/babul or gum Arabic tree – *Vachellia nilotica*, phulai, kao or Indian olive, west Himalayan alder *Alnus tida*, Indian willow – *Salix tetrasperma*, common fig, kamala or kumkum tree – *Mallotus philippensis*, amaltas or Indian laburnum, kachnar, chamror – *Ehretia aspera*, sweet plum – *Sageretia theezans*, pataki or royale's spike thorn, sanatha, common buck thorn – *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 binata*, buffel grass – *Cenchrus ciliaris*, khabbal – *Cynodon dactylus* and other turf grasses. However, 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.

***Dob Ghar Subtropical Broadleaved Urban Forest**:* This habitat is located 34^0 43" 36' N and 72^0 05" 56' E and 3365 feet above mean sea level (amsl) and may range from 3942 to 4487 feet amsl (Fig 1) in the hilly terrain dominated with small trees and shrubs e.g. phulai, kao or Indian olive, sanatta, yellow Himalayan rasberry, shrubby blackberry, mallah ber and variety of grass species.

***Kamal Khan Subtropical Broadleaved Urban Forests**;* This habitat occurs at latitude 34^0 42" 32' N and longitude 72^0 05" 53' E and 3428 feet above mean sea level and may range from 3017 to 3966 feet amsl (Fig 1) and comprised of hilly terrain and riparian areas. These areas densely covered with fruiting trees, e.g., common fig, white toot/mulberry, white toot/mulberry, paper mulberry – *Broussonetia papyrifera,* bhimal – *Grewia optiva,* bakain or dharek – *Melia azedarach,* and scrub vegetation, i.e., sanatta, yellow Himalayan rasberry, shrubby blackberry, and mallah ber.

Kityari Subtropical Broadleaved Urban Forest; This habitat is located within 34^0 44" 46' N and 72^0 04" 29' E and 2985 feet amsl and may range from 2968 to 3125 feet amsl (Fig 1) and encompasses hilly terrain ridges that are covered by coniferous vegetation on a higher elevation (chir pine – *Pinus roxburghii*) and scrub vegetation, such as sanatta, yellow Himalayan rasberry, shrubby blackberry, and mallah ber in foothills.

***Palamar Subtropical Broadleaved Urban Forest**;* This habitat is situated at 34^0 46" 46' N and 72^0 0" 04' E quadranrt and 3459 feet amsl and may range from 4044 to 4959 feet amsl (Fig 1). It is a transition zone between coniferous and scrub vegetation, surrounded by agricultural fields. It is dominated with chir pine, kao, kamla, sanatha, anar, pataki, bhaikar, and barbery, etc.

Seya Sar Subtropical Broadleaved Urban Forest occurs within the 34^0 47" 44' N and 72^0 01" 26' E and 3682 feet amsl and may range from 5015 to 5822 feet amsl (Fig 1) along the inner ridges of the mountains and occupied with bakain or dharek, white toot/mulberry, white toot/mulberry, olive, sanatha, bkaikar, and barbery etc.

Shahabad Subtropical Broadleaved Urban Forests; It is located 34^0 45" 31' N altitude and 71^0 59" 47' E longtitude and 3388 feet and may range from 3319 to 3775 feet amsl (Fig 1). Evergreen vegetation comprising of chir pine, olive, sanatha, bhaikkar and grasses is sparsely scattered.

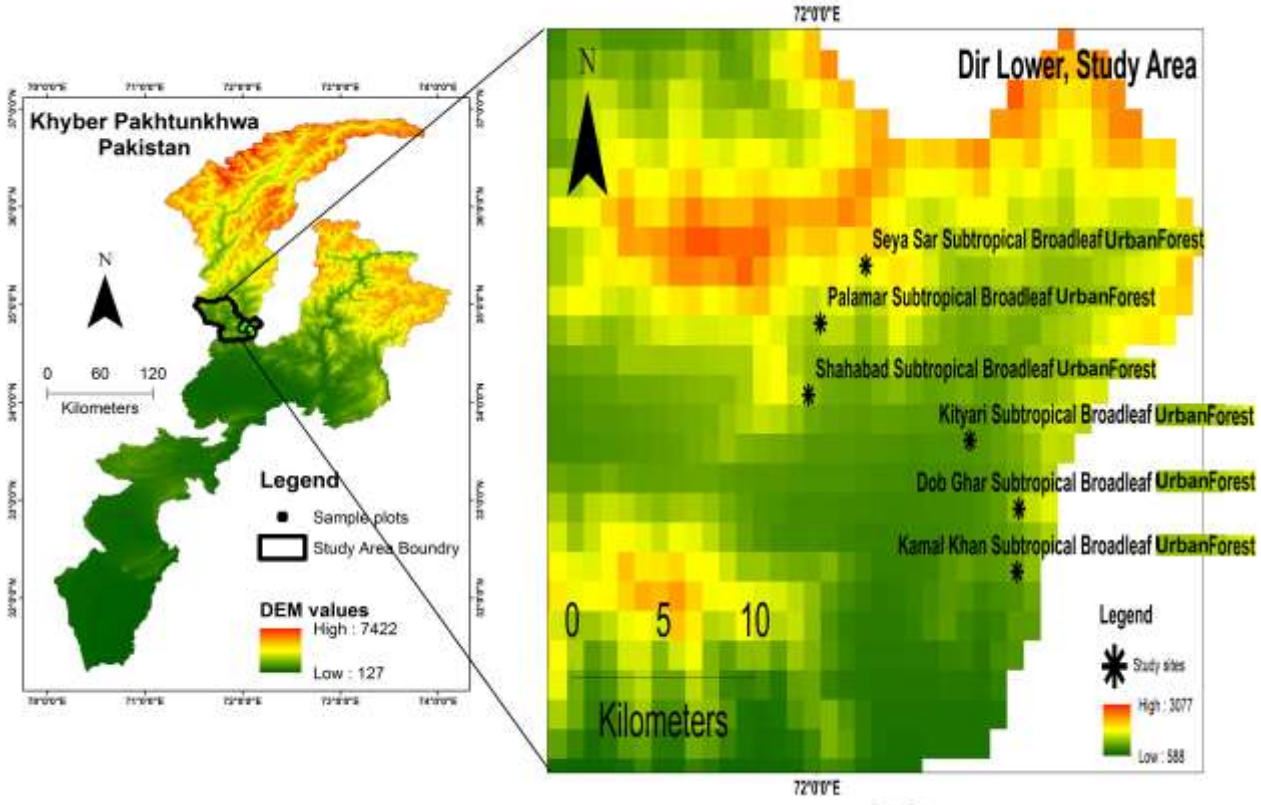

Figure 1: Location map of the study area

Bird Survey**:** Distance sampling line transect is the robust and is the robust, adequate and most efficient method to identify avian populations in different habitats (Buckland et al., 2001; Cassey et al., 2007; Green et al., 2010) to analyze density in heterogenous habitats, i.e. to sample bird density in environmental gradients (Broekema and Overdyck, 2012). This technique enabled the perpendicular distance between the bird and the observer to be determined by means of a visual approximation (Figure 2). DISTANCE computes x values which can be used to measure population density (Buckland et al., 2004).

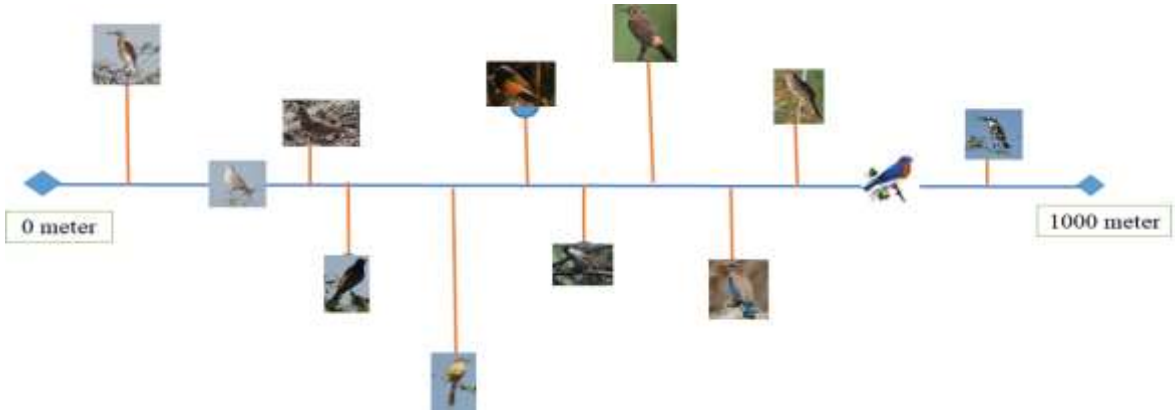

Figure 2: A view of distance sampling line transect method

Bird detection accuracy and reliability depend on environmental conditions, species activity and observer skills (Diefenbach et al., 2003; Marques et al., 2007; Innes et al., 2012). The problem of variable detection is solved by distance sampling and accurate density estimates are given (Buckland, 2006). A total of 120 transect lines were randomized over a hilly topography (20 transect lines in each habitat with a length of 2 km) to assess bird occupancy in each habitat. Birds were detected early in the morning from 7:30 a.m. to 11:00 a.m. December 2017 from November 2018. All the birds seen and heard were reported in each survey. By visual evaluation, the perpendicular distance between the birds and the transect line was reported. Opportunistic observations of airborne birds of unknown origin were also reported, but were not included in the study. Buckland et al. (2004), Gregory et al. (2006), Aborn (2007) and Nadeau et al. were the basis for the sampling method (2008).

DATA ANALYSIS

***Relative Abundance*:** The relative abundance (%) of bird species was alculated using the expression: n/N x 100 (*Where*, n is the number of a particular bird species and N is the total number of all species).

Bird density: For future conservation and management planning and to check the current status of bird species in a given habitat, the determination of the exact population size is very important. Bird density was calculated by the Buckland et al. software DISTANCE (version 6.1) (2004). The key to distance sampling is to use the distribution of observed distances to determine the "sensing function", g (y), the probability of estimating a bird from a distance y. This function can then be used to measure the mean probability of detection of a bird given that it is inside w of the point, Pa. Provided a Pa estimate, the density of birds can be calculated as:

$$\hat{D} = \frac{1}{a} \sum_{i=1}^{n} \frac{1}{\hat{P}_a(\mathbf{z}_i)}$$

Where, *a is* the size of the covered region, *n is* the number of birds seen, and *P^ a* (**z***i*) is the estimated probability of detecting the *i*th bird given that it is within *w* of the line and has the covariate values **z***i* (Marsden, 1999; Buckland et al., 2001). Based on the reduced sample size, the densities of birds of these species with fewer than 10 detections were not determined. The approach as outlined by Marsden has been followed (1999).

***Bird Diversity Indices*:** Monitoring the diversity of existing bird species is an important step in the description of the structures of bird communities and the identification of appropriate habitats. Diversity indices, such as species diversity, species richness and regularity, were identified using the Community Analysis Kit by Henderson and Seaby (2007). (CAP, version 4.0). In this study, the Shannon Diversity Index, Margalef Richness Index and McIntosh Regularity Index were used to determine avian species diversity indices in six broad-leaved forest habitats.

Species Diversity*:** Diversity is an index that takes into account the number of birds in a given ecosystem and the relative abundance and offers more details on the nature of the population, such as scarcity and avian species dominance. For example; ***Shannon's Diversity Index:

$$H' = -\sum_{i=1}^{S} p_i \ln p_i$$

Where, H' designates diversity, S indicates the number of species, *i* specifies the abundance of species, N relates to the total number of all individuals and p_i is the relative abundance of each species.

Species Richness*:** Species richness is the number of different bird species that occur in residential habitat. It also provides data on the homogeneity and scarcity of the structure of the avian population. For example; ***Margalef's Richness Index:

$$(R) = S\text{-}1/\ln (n)$$

Where, S = Σ species in the plot and n =Σ Individuals of all species.

Species Evenness*:** Uniformity is the relative abundance of individual avian species in a specific habitat.. For example; ***McIntosh's Index:

$$D = \frac{N - U}{N - \sqrt{N}}$$

Where, *N* is the total number of individuals in the sample and *U* is given by the expression:

$$U = \sqrt{\sum n_i^2}$$

Where, *n* (i) is the number of individuals in the *i*th species and the summation is undertaken over all the species, *U* is the Euclidean distance of the community from the origin.

***Comparison of Bird Diversity Indices in Six Subtropical Broadleaved Urban Forest Habitats*:** A Kruskal-Wallis one-way analysis of variance (ANOVA) and a Tukey's (HSD) test (Analytical Software, version 8.1) were used to investigate the significance of differences in diversity indices among six subtropical broadleaved forest habitats (McGraw-Hill, 2008). McGraw-Hill

***Comparison of Foraging Guild Structure in Six Subtropical Broadleaved 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 ranked in eight guilds based on dietary behaviour, food selection and habitat preferences. The method used as described by Nebel *et al.* (2005); Leso and Kropil, (2007); Burger *et al.* (2007) and Pinotti et al. (2012).

RESULTS

***Bird Species Composition and Relative Abundance*:** In total, 2879 individuals representing 53 species from 28 families and 9 orders detected in six subtropical urban broadleaved forest habitats, i.e. Shahabad (51 species; 515 birds), Seya Sar (47 species; 437individuals), Palamar (46 species; 445 detections), Kamal Khan (50 species; 497 individuals), Dob Ghar (45 species; 391 individuals) and Kityari (49 species; 594 individuals). Out of 53 bird species, one species was vulnerable (VU) while 52 other species were least of concern (SC) according to the IUCN Red List. Relative abundance of avian species may vary from habitat to habitat. For example; common myna (35, 32, 21 detections) in Shahabad, Kamal Khan and Dob Ghar; scarlet rosefinch (35 detections) in Seya Sar; chakor (35 detections) in Palamar; and house crow (80 detections) in Kityari were the most dominant bird species within six forest habitats. In contrast, shikra and speckeled 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, i.e., each recorded only once (Table 1).

Table 1: List of bird species detected in six broadleaf urban forest habitats

S. No.	Scientific Name	Common Name	Name of Habitat (Urban Forest)						
			Shahabad	Seya Sar	Palamar	Kamal khan	Dob Ghar	Kityari	IUCN Status
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**						

The abundance ranking curve showed the distribution patterns of relative abundance of birds in six subtropical deciduous persistent forests. The abundance classification curve provides information on abundance, proportionate abundance, logarithmic abundance, and accumulated proportionate abundance. The abundance curve is a 2D graphic with relative abundance on the Y axis and abundance rank on the X axis. The graph indicates that the relative abundance of birds in six habitats can vary between habitats. The curve shows the distribution of bird species, i.e. the steep slope shows low regularity because high-ranking species show higher abundance than low-ranking species. In addition, the shallow gradient has the highest consistence (Figure 3).

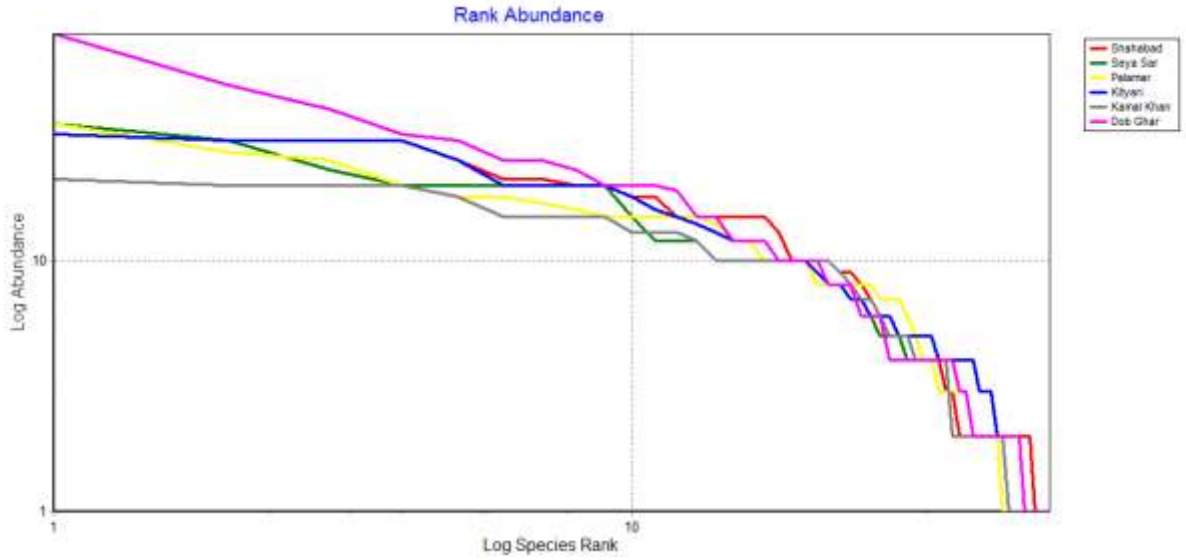

Figure 3: Rank abundance curve of bird relative abundance among six subtropical broadleaved evergreen urban forests

***Comparison of Bird Density in Six Subtropical Broadleaved Urban Forest Habitats*:** The findings showed that the more active habitats supporting the higher bird population were Palamar (0.954 ± 0.221 birds/ha) and Kityari (0.938 ± 0.162 birds/ha). In comparison, Kamal Khan's broad-leafed subtropical habitat (0.102 ± 0.178 birds/ha) was less productive and favoured by avian species (Table 2).

Table 2: Habitat wise bird density in six subtropical broadleaved urban forest habitats

Habitat	**Density (birds/ha)**
Palamar	0.954 ± 0.221
Kityari	0.938 ± 0.162
Dob Ghar	0.874 ± 0.230

Shahabad	0.870 ± 0.147
Seya Sar	0.808 ± 0.209
Kamal Khan	0.102 ± 0.178

Bird Density in Dob Ghar Subtropical Broadleaved Urban Forest: The results revealed that Black–throated thrush (0.966 ± 0.329 / ha), Indian paradise flycatcher (0.896 ± 0.326 / ha) and common rosefinch (0.833 ± 0.259 / ha) were the three most populated bird species that preferred to utilize the Dob Ghar subtropical broadleaved urban forest. However, the density of 23 bird species was not processed due to the small sample size i.e. less than 10 individual detections (Table 3).

Bird Density in Shahabad Subtropical Broadleaved Urban Forest: Distance test results indicated that five bird species viz., large-billed crow (0.833 ± 0.270 / ha), common starling (0.823 ± 0.283 / ha), common chiffchaff (0.757 ± 0.244 / ha), common myna (0.733 ± 0.203 / ha), and streaked laughing thrush (0.729 ± 0.295 / ha) dominantly inhabited the Shahabad subtropical evergreen broadleaf urban forest. However, the density of 29 bird species was not determined due to the low number of bird individual detections (Table 3).

Bird Density in Kityari Subtropical Broadleaved Urban Forest: In Kityari subtropical broadleaved urban forest the highest bird density was determined in black drongo (0.996 ± 0.266 / ha), bay–backed shrike (0.771±0.259 / ha), red–vented bulbul (0.756 ± 0.242 / ha), and common babbler (0.717 ± 0.186 / ha). However, the density of 28 bird species was not examined due to the low number of bird individuals' detections (Table 3).

Bird Density in Seya Sar Subtropical Broadleaved Urban Forest: The findings indicated that cinereous tit (0.926 ± 0.324 / ha) and Eurasian tree sparrow (0.716 ± 0.268 / ha) were the most dominant bird species that densely occupied the Seya Sar subtropical evergreen broadleaved urban forest. Furthermore, the density of 28 bird species was not examined due to the small sample size (Table 3).

Bird Density in Kamal Khan Subtropical Broadleaved Urban Forest: The findings of this study indicated that house sparrow and common babbler were the most dominant bird species that had the highest bird density (0.961 ± 0.307 / ha and 0.887 ± 0.249 / ha) in Kamal Khan subtropical broadleaved forest habitat. In contrast, the density of 30 bird species was not analyzed due to the small sample size (Table 3).

Bird Density in Palamar Subtropical Broadleaved Urban Forest: The results of Distance analysis showed that common myna (0.868 ± 0.284 / ha), common babbler (0.790 ± 0.253 / ha), cinereous tit (0.757 ± 0.235 / ha), and black–throated thrush (0.732 ± 0.281 / ha) were the four most abundant bird species having the highest bird density in Palamar subtropical broadleaved urban forest habitat. On the contrary, the density of 26 bird species was not analyzed due to small sample size (Table 3).

Table 3: Bird density in six subtropical broadleaved urban forests; Abundance in descending order.

Scientific Name	**Common Name**	**Density (birds/ha)**					
		Name of the Habitat (Urban Forest)					
		Dob Ghar	Shahabad	Kityari	Seya Sar	Kamal Khan	Palamar
Streptopelia chinensis	Spotted dove	–	–	–	0.406 ± 0.114	–	0.578 ± 0.210
Alectoris chakur	Chakur	0.735 ± 0.237	0.162 ± 0.553	–	0.109 ± 0.363	–	0.347 ± 0.965
Coturnix coturnix	Common quail	0.696 ± 0.307	0.158 ± 0.817	0.129 ± 0.855	0.158 ± 0.778	0.263 ± 0.153	0.173 ± 0.824
Corvus splendens	House crow	–	0.303 ± 0.119	0.386 ± 0.302	0.241 ± 0.121	0.241±0.168	–
Corvus macrorhynchos	Large-billed crow	0.252 ± 0.101	0.833 ± 0.270	–	0.168 ± 0.459	–	0.252 ± 0.975
Dicrurus macrocercus	Black drongo	0.103 ± 0.391	0.166 ± 0.732	0.996 ± 0.266	0.151 ± 0.432	0.131 ± 0.326	0.136 ± 0.504
Emberiza cia	Rock bunting	0.108 ± 0.419	0.694 ± 0.210	–	0.127 ± 0.487	–	–
Carpodacus erythrinus	Common rosefinch	0.833 ± 0.259	0.617 ± 0.177	0.558 ± 0.203	0.574 ± 0.183	0.694 ± 0.212	0.254 ± 0.111
Hirundo rustica	Common swallow	0.108 ± 0.353	0.648 ± 0.175	0.228 ± 0.170	0.129 ± 0.425	0.196 ± 0.119	–
Lanius tephronotus	Grey-backed shrike	0.103 ± 0.376	0.694 ± 0.289	0.133 ± 0.480	0.123±0.476	–	–
Lanius vittatus	Bay-backed shrike	–	–	0.771 ± 0.259	–	–	–
Turdoides caudata	Common babbler	0.641 ± 0.231	0.525 ± 0.173	0.717 ± 0.186	0.222 ± 0.737	0.887 ± 0.249	0.790 ± 0.253
Trochalopteron lineatum	Streaked laughing thrush	0.205 ± 0.525	0.729 ± 0.295	0.101 ± 0.340	–	0.109 ± 0.417	0.694 ± 0.249
Terpsiphone paradisi	Indian paradise flycatcher	0.896 ± 0.326	0.120 ± 0.365	0.176 ± 0.697	0.164 ± 0.558	0.144 ± 0.420	0.121 ± 0.445
Motacilla alba	White wagtail	–	–	0.241 ± 0.152	–	0.378 ± 0.253	0.317 ± 0.197
Oriolus oriolus	Golden oriole	0.548 ± 0.259	–	0.616 ± 0.220	0.450 ± 0.162	0.635 ± 0.214	0.612 ± 0.205
Parus cinereus	Cinereous tit	0.119 ± 0.387	0.694 ± 0.238	0.109 ± 0.289	0.926 ± 0.324	0.160 ± 0.471	0.757 ± 0.235
Passer montanus	Eurasian tree sparrow	0.264 ± 0.113	0.168 ± 0.367	0.520 ± 0.151	0.716 ± 0.268	0.264 ± 0.180	0.100 ± 0.310
passer domesticus	House sparrow	0.138 ± 0.404	0.617 ± 0.196	0.119 ± 0.308	0.222 ± 0.109	0.961 ± 0.307	0.241 ± 0.126
Phylloscopus collybita	Common chiffchaff	0.126 ± 0.430	0.757 ± 0.244	0.144 ± 0.582	–	0.120±0.406	0.108 ± 0.379
Phylloscopus chloronotus	Lemon-rumped warbler	0.104 ± 0.319	–	0.114 ± 0.480	–	–	–
Phylloscopus trochiloides	Greenish warbler	–	–	–	–	0.126 ± 0.467	–
Pycnonotus cafer	Red-vented bulbul	0.747 ± 0.253	0.177 ± 0.348	0.756 ± 0.242	0.124 ± 0.391	0.129 ± 0.459	0.669 ± 0.200
Pycnonotus leucotis	White-eared bulbul	0.173 ± 0.636	–	–	–	0.195 ± 0.405	–
Pycnonotus leucogenys	Himalayan bulbul	–	0.617 ± 0.202	–	–	0.120 ± 0.391	0.252 ± 0.840
Acridotheres tristis	Common myna	0.106 ± 0.246	0.733 ± 0.203	0.105 ± 0.308	0.101 ± 0.382	0.142 ± 0.514	0.868 ± 0.284
Acridotheres ginginianus	Bank myna	–	–	–	–	–	–
Sturnus pagodarum	Brahminy starling	–	0.119 ± 0.412	0.264 ± 0.135	–	–	–
Sturnus vulgaris	Common starling	0.666 ± 0.219	0.823 ± 0.283	0.666 ± 0.236	0.100 ± 0.295	–	0.666 ± 0.231
Turdus atrogularis	Black-throated thrush	0.966 ± 0.329	0.104 ± 0.319	–	0.555 ± 0.189	0.115 ± 0.400	0.732 ± 0.281

***Comparison of Bird Diversity Indices in Six Subtropical Broadleaved Urban Forest Habitats*:** Community Analysis Package test illustrated that bird diversity in six subtropical broadleaved urban forests varied i.e. the Dob Ghar (H' = 33.92 ± 1.368) habitat was more diverse in avian species composition and Kityari (H' = 20.78 ± 1.368) was the least diverse as compared to other habitats. In addition, Pooled Rarefaction and Diversity Ordering – Renyi test was also run to compare the relative diversity and richness differences among six habitats (Figure 4 and 5). Notably, the highest avian richness was determined in Shahabad (R_1 = 8.007 ± 0.053) and the least richness found in Dob Ghar (R_1 = 7.372 ± 0.053). Likewise, the avian species were evenly distributed in Dob Ghar (E = 0.9657 ± 0.004) and sparsely in Kityari (E = 0.9065 ± 0.004) respectively (Table 4 and Figure 6).

Table 4: Habitat wise bird diversity indices in six subtropical broadleaved urban forests

Habitat	**Shannon's Index (H)**	**Margalef's Index (R_1)**	**McIntosh's Index (E)**
Dob Ghar	33.92	7.372	0.9657
Palamar	30.74	7.379	0.9544
Kamal Khan	30.66	7.892	0.9482
Shahabad	30.06	8.007	0.9468
Seya Sar	29.11	7.566	0.9469
Kityari	20.78	7.515	0.9065
Standard Error	1.368	0.053	0.004
Overall	31.69	6.528	0.9522

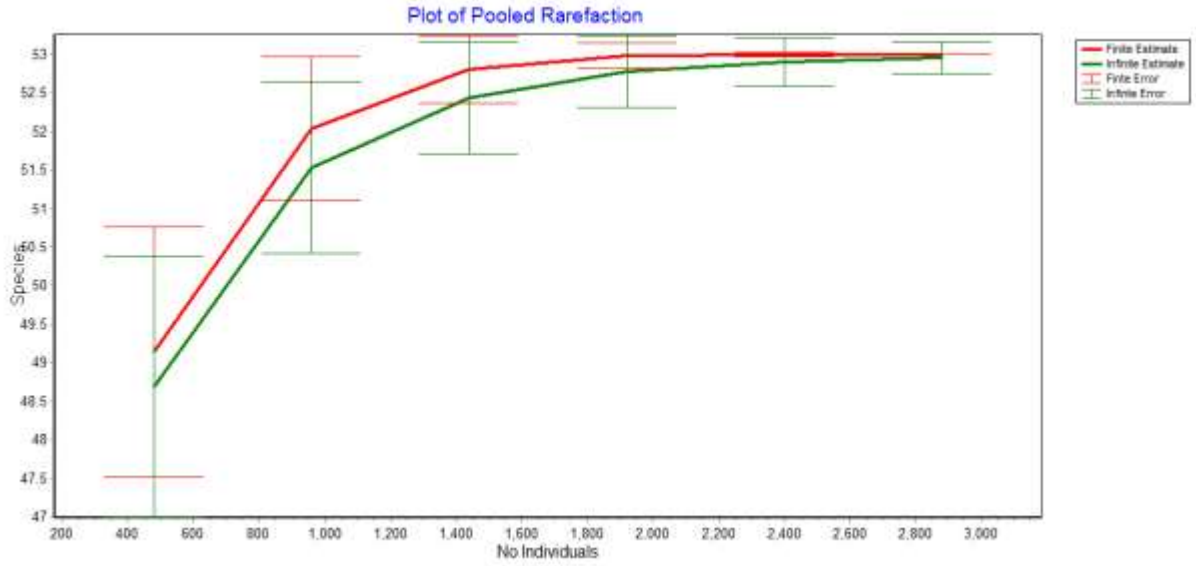

Figure 4: Comparisons of species richness (Pooled Rarefaction Plot) of bird communities in six subtropical broadleaved urban forests

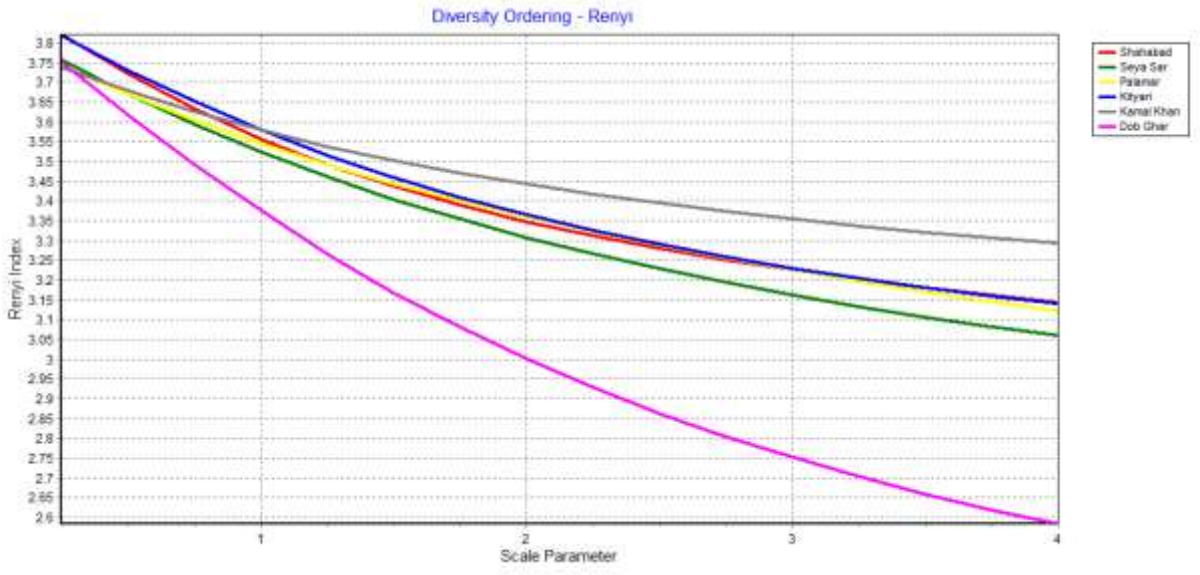

Figure 5: Comparison of relative diversity change (Diversity Ordering – Renyi) in six subtropical broadleaved urban forests

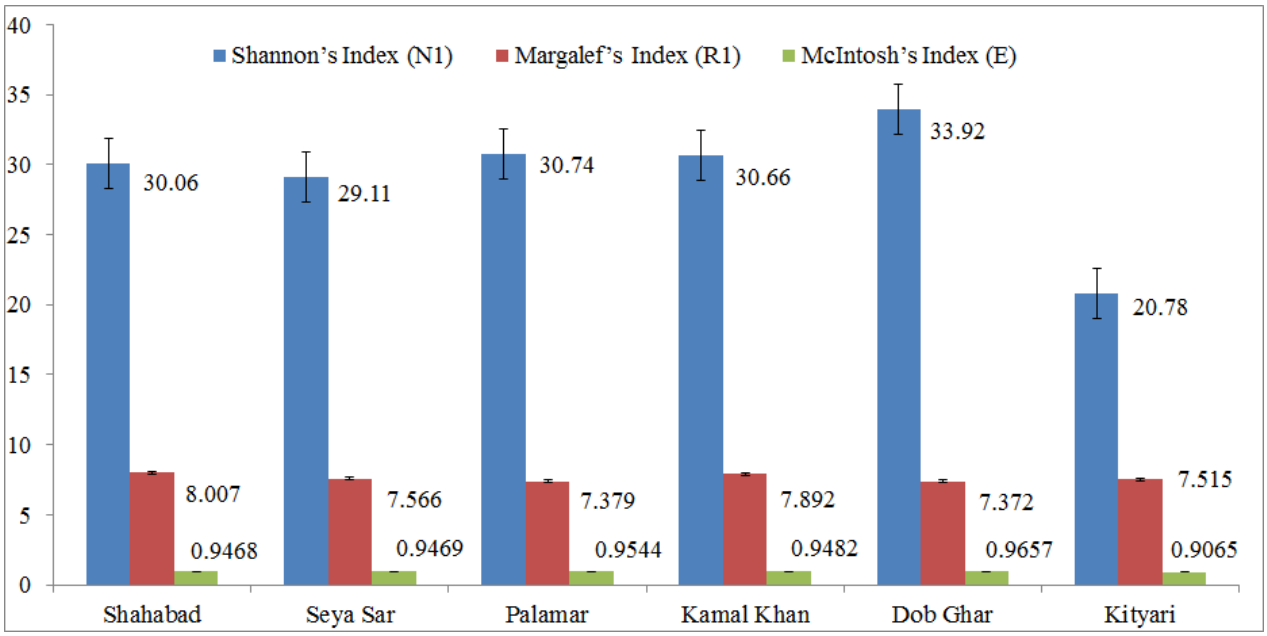

Figure 6: Comparison of diversity indices in six subtropical broadleaved urban forest habitats

Furthermore, the branch lengths and topological changes of dendrogram highlighted that avian diversity may vary from habitat to habitats (Figure 7).

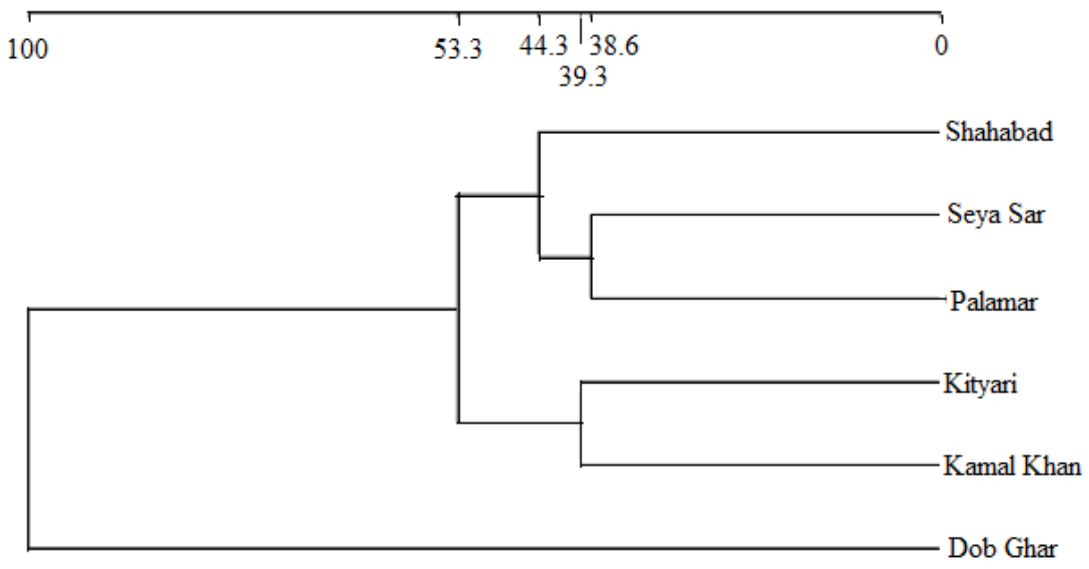

Figure 7: Dendrogram indicating bird diversity in six subtropical broadleaved urban forest habitats

***Comparison of Bird Diversity Indices in Six Subtropical Broadleaved Urban Forest Habitats*:** Kruskal-Wallis One–Way ANOVA and Tukey's HSD indicated that the bird diversity indices in six subtropical broadleaved urban forest habitats were significantly different ($F_{5,\ 17} = 61.7$, $p < 0.05$).

***Comparison of Foraging Guilds of Avian Species in Six Subtropical Broadleaved Urban Forest Habitats*:** The results of foraging guilds revealed that foraging guilds of avian species may vary from habitat to hbitat. Insectivore were the most abundant bird species (Greenish warbler, Lemon–rumped warbler, Common chiffchaff, Cinereous tit, Oriental magpie robin, Pied bushchat, 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) that heavily utilized all habitats. Likewise, Omnivore (5.592%) heavily occupied the Kityari urban forest habitat. In contrast, Carnivore/Piscivore/Insectivore (White–throated kingfisher) avoided to use Dob Ghar and Furgivore (Speckled wood pigeon and Yellow–footed green pigeon) also avoided to visit Kamal Khan and Dob Ghar urban forest habitats (Table 5).

Table 5: Compariosn of foraging guilds in six subtropical broadleaved urban forests

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**			

DISCUSSION

A comprehensive evaluation of avian diversity demonstrates the habitat-level ecosystem health that is paramount in conservation activities (Stem et al., 2005) since it exposes the details that explain the driving forces that affect population variability directly or indirectly. The birds are bio-indicators of habitat health and productivity (Gregory and Strien, 2010; Goteli and Chao, 2013). The detailed knowledge on the parameters of the bird population helps to

explain the key driving factors that play an important role in the home range, the selection of habitats and the effect of human interference on avian diversity and habitat alteration (Raman, 2006; Buxton et al., 2018).

Determining the conservation status and population structure of avian species living in various broadleaved subtropical urban forests has provide a solid foundation for better understanding of ecological trends and processes. The results of this study indicated that by providing a wide variety of food resources and niches and harsh environments, avian diversity will increase with heterogeneous habitats. Less vegetated habitats, by comparison, were favoured only by some animals. With landscape diversity, species abundance increases and decreases with less coverage of vegetation due to the lack of food resources (Koadmon et al., 2007; Bar–Massada and Wood, 2014; Lee and Martin, 2017).

The conservation status and population structure of avian species living in various subtropical broad-leaved urban forests provided information on the scarcity and abundance that will assist in future conservation and management planning. The most active, diverse, and complex ecosystems that covered about 30-40 percent of Pakistan's forested area were subtropical broadleaved urban forests. However, these urban forests are of vital significance for the protection of both wildlife and human beings (Waring and Running, 2007; WBD, 2018). These urban forests, sadly, are deforested, degraded, isolated and converted into agricultural fields, human settlements that have decreased bird populations negatively..

In particular, records of 53 bird species have shown that urban forests are of critical importance for avian species. The results of the Distance Analysis and CAP test suggested that the indices of bird density and diversity can differ across six subtropical broad-leaved urban forests. This indicates that the range of habitats among bird species which vary depending on the composition of the vegetation, the availability of food resources (e.g. insects, fruits, grains, amphibians, reptiles and small mammals), adjacent habitats, i.e. agricultural fields and orchards offering acceptable forage and breeding sites, and human intervention. The other explanation may be that these bird species belong to various foraging guilds, i.e., in heterogeneous environments, they forage and eat a range of food resources. Thrushes, for instance, frequently prefer dense scrub vegetation stands, forest edges, wet ditches and grassy areas to feed on invertebrates such as caterpillars, ants, wasps, grasshoppers, beetles and wing flies.

Furthermore, they also hunt for invertebrates such as centipedes and millipedes in leaf litter. For invertebrates, i.e. larvae, caterpillars, worms, and ants, Babblers pick relatively open woodlands, scrub plants, forest remains, and forest edges to forage. Thickets, woodlands, forest edges near riparian regions and orchards for seeds, buds, shoots, fruits and orchards for foraging are often favored by finches. Pigeons rely on a variety of fruits on fruiting trees to forage. As grassy areas are rich in grains and insects, Francolins and Chakor prefer barren hills dominated by grasses and sparse shrub vegetation and also provide hiding cover from predators and ideal breeding sites. In addition, they also hunt for invertebrates in leaf litter, such as centipedes and millipedes. Relatively open woodlands, scrub plants, forest remains, and forest edges are picked by babblers to forage. For seeds, buds, shoots, berries, and fruit forage, finches often choose thickets, woodlands, forest edges near riparian areas, and orchards.

A record of five species of raptors, namely, shikra, besra, kites, kestrels and owls, showed that these subtropical broadleaved urban forests are an attractive habitat for passerine birds, reptiles (lizards and snakes), small mammals (shrews, rats, squirrels, and mice). The other explanation may be that in these urban forests, these birds are hunting in nearby habitats and eating their prey. Similarly, in higher numbers, insectivore birds such as minivets, woodpeckers, bee-eaters, flycatchers, wagtails, robins, bushchats, warblers, shrikes, and tree-creepers were reported. The diversity of insect-eating birds may be due to the richness and diversity of insects, such as flies, moths, beetles, grasshoppers, caterpillars, wasps, ants, and termites, which are their staple diet. This may be due to the presence of trees, shrubs, and grasses that also bear flowers and fruits that are fruiting and flowering. Similarly, adequate numbers of game birds, i.e. francolin, chakor, quails, and doves were also found. These birds have also chosen grasses and open landscapes to feed on seeds, grass grains, crops for agriculture and cereals.

In addition, frugivore/insectivore birds were also detected in good numbers, such as starlings, orioles, thrushes and bulbuls. The phenomenon of a large number of birds eating fruit and insects may be attributed to the presence of a variety of fruits and insect diversity. The other explanation may be that agricultural fields and orchards have surrounded these forests, sometimes bearing flowers and juicy fruits that attract a wide variety of insect species to make use of these adjacent habitats. This shows that birds are habitat specialists, choose suitable environments, rich food supplies, ideal forage and breeding sites, and shelter for them (Whelan, 2001; Robertson et al., 2013; Cloyed, 2014; Mansor et al., 2015; Styring and Sheldon, 2016).

CONCLUSIONS

Overall, the findings of this study show that subtropical wide-leaved urban forests are active, abundant, and complex habitats that have attracted a broad variety of avian species from higher bird populations to use them. It is therefore strongly suggested that these urban forests should be designated as reserved forests in order to increase the population of highly endangered and threatened avian species.

Acknowledgments: The authors acknowledge the financial support of Universiti Putra Malaysia and the Timergrah Wildlife Department, Khyber Pakhtunkhwa, to carry out this important research work.
Conflicts of Interest: Authors declare no conflict of interest.

REFERENCES

Aborn, D.A. 2007. Abundance, Density and Diversity of Neotropical Migrants at the Lula Lake Land Trust, GA. *Southeastern Naturalist*, 6(2): 293–304.

Alvey, A.A., 2006. Promoting and preserving biodiversity in the urban forest. *Urban For Urban Gree*, 5(4): 195–201.

Bar–Massada, A. and Wood, E.M., 2014. The richness-heterogeneity relationship differs between heterogeneity measures within and among habitats. *Echography*, 37: 528–535.

Broekema, I. and Overdyck, O., 2012. Distance sampling to estimate densities of four native forest bird species during multispecies surveys. *New Zealand Journal of Ecology*, 36(3): 1–12.

Buckland, S.T., Anderson, D.R., Burnhan, K.P., Lake, J.L., Borchers, D.L. and Thomas, L., 2004. Advance Distance Sampling; Estimating Abundance of Biological Populations. *London; Campman and Hall*. Pp.141–172.

Buckland, S.T. 2006. Point transect surveys for songbirds: robust methodologies. *The Auk*, 123–375.

Buckland, S.T., Anderson, D.R., Burnham, K.P., Laake, J.L., Brochers, D.L. and Thomas, L., 2001. Introduction to Distance Sampling: Estimating Abundance of Biological Populations. Oxford University Press, UK. ISBN: 0198509278.

Burger, J., Carlucci, S.A., Jeitner, C.W. and Niles, L., 2007. Habitat choice, disturbance, and management of foraging shorebirds and gulls at a migratory stopover. *J. Coast. Resear*., 235(5): 1159–1166.

Buxton, R.T., Agnithori, S., Robin, V.V., Goel, A. and Balakrishnan, R., 2018. Acoustic indices as rapid indicators of avian diversity in different land–use types in an Indian Biodiversity hotspot. *Journal of Ecoacoustics*, 2: 1–15.

Cassey, P., Craig, J.L., McArdle, B.H. and Barraclough, R.K., 2007. Distance sampling techniques compared for a New Zealand endemic passerine (*Philesturnus carunculatus rufusater*). *New Zealand Journal of Ecology*, 31: 223–231.

Chazdon, R.L., 2008. Beyond deforestation: Restoring forests and ecosystems services on degraded lands. *Science*, 320: 1458–1460.

Clements, P. and Christie, D.A., 2019. Common Rosefinch (Carpodacus erythrinus). In: del Hoyo, J., Elliott, A., Sargatal, J., Christie, D.A. and del Juana, E. (Eds). *Handbook of the Birds of the World Alive*. Lynx Edicions, Barcelona. Web Accessed on 10th April, 2019 at *URL://www.hbw.com/node/61386*.

Cloyed, C.S. (2014). Forest structure affects resource portioning between pygmy and white-breasted nuthatches. *Coevolution*, 2(1): 26–30.

DeWalt ,S.J., Maliakal, S.K. and Denslow, J.S. 2003. Changes in vegetation structure and composition along a tropical forest chronosquence: Implications for wildlife. *Forest Ecology and Management*, 182: 139–151.

Diefenbach, D.R., Brauning, D.W. and Mattice, J.A., 2003. Variability in grassland bird counts related to observer differences and species detection rates. *The Auk*, 120: 1168–1179.

FAO (1997). Asia-Pacific Forestry Sector Outlook Study. Working Paper Series, Asia-Paific Forestry towards 2010. Working Paper No: APFSOS/WP/11. Forestry Policy & Planning Division, Rome, Italy.

Fisher, B., 2010. African exception to drivers of deforestation. *Nature Geoscience*, 3: 375–376.

Goteli, N.J. and Chao, A., 2013. Measuring and estimating species richness, species diversity and biotic similarlity from sampling data. In: *Encyclopedia of Biodiversity*, Volume 5 (Levin, S.A. Eds.) *Academic Press*, 195–211pp.

Gray, M., Baldauf, P., Mayhew, P. and Hill, J., 2007. The response of avian feeding guilds to tropical forest disturbance. *Conservation Biology*, 21: 133–141.

Green, T., Jones, A., Dennis, G. and Sachtleben, T., 2010. Distance sampling to determine the kaka (*Nestor meridionalis septentrionalis*) density within Waipapa ecological area, Pureora. *New Zealand Journal of Ecology*, 34: 297–305.

Gregory, R.D. and Strien, A.V., 2010. Wild bird indicators: using composite population trends of birds as measures of environmental health. *Ornithological Science*, 9(1): 3–22.

Gregory, R.D., Gibbons, D.W. and Donald, P.F., 2006. Bird census and survey techniques. In: Bird Ecology and Conservation, *A Handbook of Techniques*. (Eds.) W.J. Sutherland, I. Newton and R.E. Green. 386 pp.

Hansen, M.C., Stehman, V. and Potapove, P.V., 2010. Quantification of global gross forest covers loss. *Proceedings of the National Academy of Science*, 107: 8650–8655.

Hemandez–Stefanomi, J.L., Dupuy, J.M., Tun–Dzul, F. and May–Pat, F., 2011. Influence of landscape structure and stand age on species density and biomass of a tropical dry forest across spatial scale. *Landscape Ecology*, 26: 355–370.

Henderson, P.A. and Seaby, R.M.H., 2007. Community Analysis Package 4.0. *Pisces Conservation Ltd, Lymington, UK.*

Innes, J., Spurr, E.B., Arnold, G.C., Morgan, D., Waas, J.R. and Watts, C., 2012 Using five-minutes bird counts to study magpie (*Gymnorhina tibicen*) impacts on the birds in New Zealand. *New Zealand Journal of Ecology*, 36: 324–332.

IUCN., 2004. Guidelines for using the IUCN Red List Categories and Criteria. *IUCN, Gland, Switzerland and Cambridge, UK*.

Koadmon, R and Alloche, O., 2007. Intergrating the effects of area, isolation, and habitat heterogeneity on species diversity: a unification of island biogeograpgy and niche theory. *Am. Nat.,* 170: 443–454.

Kotiaho, J.S., Kaitala, V., Komonen, A. and Palvinen, J., 2005. Predation the risk of extinction from shared ecological characteristics. *Proceedings of the National Academy of Sciences of the United States of America*, 102: 1963–1967.

Lamb, D., Erskine. P.D. and Parrota, J.A., 2005. Restoration of degraded tropical forest landscape. *Science*, 310: 1628–1632.

Lee, M–B. and Martin, J.A., 2017. Avian species and functional diversity in agriculture landscapes: Does landscape heterogeneity matter? *PloSONE,* 12(1): e0170540.

Leso, P. and Kropil, R. (2007). A comparison of three different approaches for the classification of bird foraging guilds: an effect of leaf phenophase. *Folia Zool*., 56(1): 51–70.

Mansor, M.S., Ramli, R. and Sha, SAM., 2015. The foraging tactics of Chestnut-winged Babbler (*Stachyris erythroptera*) and Abbott's Babbler (*Malacocincla abbott*) in a lowland rainforest, Malaysia. *Sains Malaysiana*, 44(5): 687–692.

Marques, T.A., Thomas, L., Fancy, S.G. and Buckland, S.T., 2007. Improving estimates of bird density using multiple covariate distance sampling. *The Auk*, 124: 1229–1243.

Marsden, S.J., 1999. Estimation of parrot and hornbill densities using a point count distance sampling method. *Ibis*, 141: 377–390.

McGraw-Hill, C., 2008. Statistix 8.1; Analytical Software. Tallahassee, Florida Maurice/ Thomas text. ISBN: 0073402818.

Nadeau, C.P., Conway, C.J., Smith, B.S. and Lewis, T.E., 2008. Maximizing detection probability of wetland dependent bird during point count surveys in North–western Florida. *The Wilson Journal of Ornithology*, 120(3): 513–518.

Nebel, S., Jackson, D.L. and Elner, R.W., 2005. Functional association of bill morphology and foraging behavior in Calidrid Sandpipers. *Animal Biol*., 55(3): 235–243.

Perez–Arteaga, A., Jackson, S.F., Carrera, E. and Gaston, K.J., 2005. Priority sites for wildfowl conservation in Mexico. *Animal Conservation*, 8: 41–50.

Pinotti, B.T., Pagotto, C.P. and Pardini, R., 2012. Habitat structure and food resources for wildlife across successional stages in a tropical forest. *Forest Ecology and Management*, 283: 119–127.

Rajpar, M.N., 2018. Tropical Forest Area An Ideal Habitat for Wide Array of Wildlife Species. *In*: Tropical Forest – New Edition (Sundarshana, P., Nageswara–Rao, M., Soneji, J.R. (Eds.). *InTech Open Access, Publisher, Janeza Trdine 9, 51000 Rijeka, Croatia*. ISBN: 978–953–51–5859–2. Pp. 1–30.

Rajpar, M.N. and Zakaria, M., 2011. Bird Species Abundance and Their Correlationship with Microclimate and Habitat Variables at Natural Wetland Reserve, Peninsular Malaysia. *International Journal of Zoology*, 2011: 1–17.

Raman, T.R.S., 2006. Effects of habitat structure and adjacent habitats on the birds in tropical rainforest fragments ad shaded plantations in the Western Ghats, India. *Biodiversity and Conservation*, 15(4): 1577–1607.

Robertson, O.J., McAlpine, C., House, A. and Maron, M., 2013. Influence of interspecific competition and landscape structure on spatial homogenization of avian assemblages. *PloS One*, 28(5): e 65299.

Sher, H., Al-yemeni, M. and Sher, H., 2010. Forest resource utilization assessment for economic development of rural community in northern parts of Pakistan. *Journal of Medicinal Plant Research,* 4(12): 1197–1208.

Stem, C., Margolius, R., Salafsky, N. and Brown, M., 2005. Monitoring and evaluation in conservation: a review of trends and approaches. *Conservation Biology*, 19(2): 295–309.

Styring, A.R., Ragi, R., Zakaria, M. and Sheldon, F.H., 2016. Foraging ecology and occurrence of seven sympatric babbler species (Timaliidae) in the lowland rainforest of Borneo and Peninsular Malaysia. *Current Zool*., 62(4): 1–11.

Vazquez-Reyes, L.D., Arizmendi, M.D.C., Godínez-Alvarez, H.O. and Navarro-Siguenza, A.G., 2017. Directional effects of biotic homogenization of bird communities in Mexican seasonal forests. *The Condor*, 119(2): 275–288.

Waring, R.H. and Running, S.W., 2007. Forest Ecosystem. Third Edition. *Academic Press*, Pp. 420. ISBN: 978-0-12-370605-8

Whelan, C.J., 2001. Foliage structure influences foraging of insectivorous forest birds: an experimental study. *Ecol.*, 82(1): 219–231.

World Bank Data., 2018. Web accessed on 22nd November, 2018 at URL: https://data.worldbank.org/indicator/AG.LND.FRST.ZS

Wright, S.T. and Muller-Landau, H.C., 2006. The future of tropical forest species. *Biotropica,* 38: 287–301.

Figures

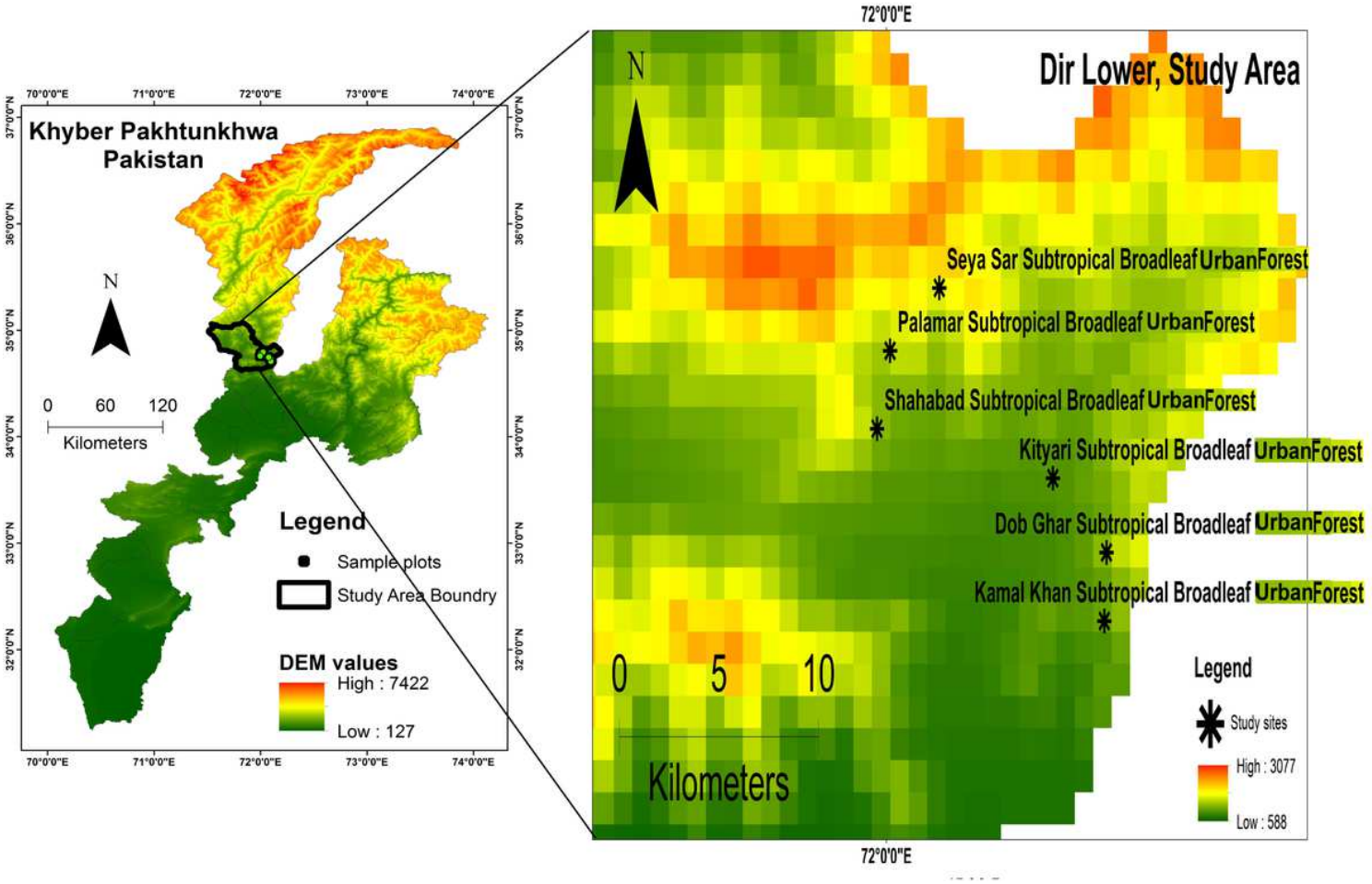

Figure 1

Location map of the study area Note: The designations employed and the presentation of the material on this map do not imply the expression of any opinion whatsoever on the part of Research Square concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. This map has been provided by the authors.

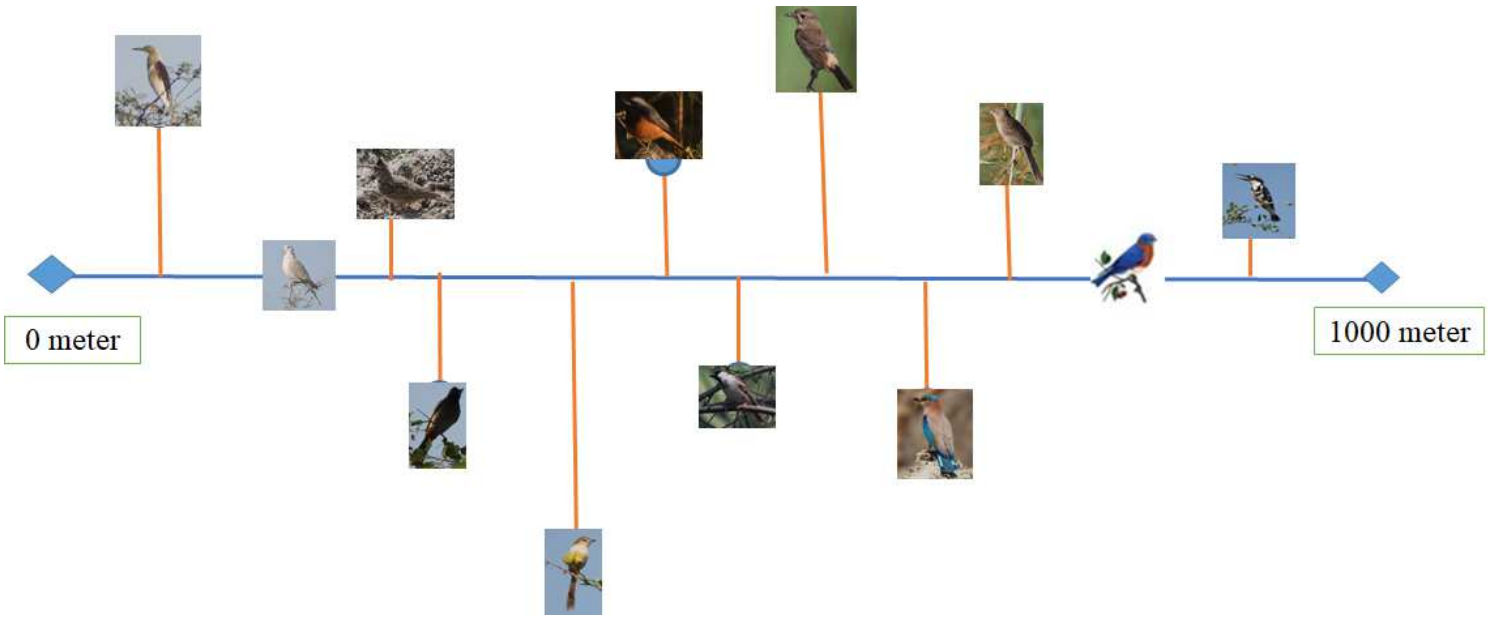

Figure 2

A view of distance sampling line transect method

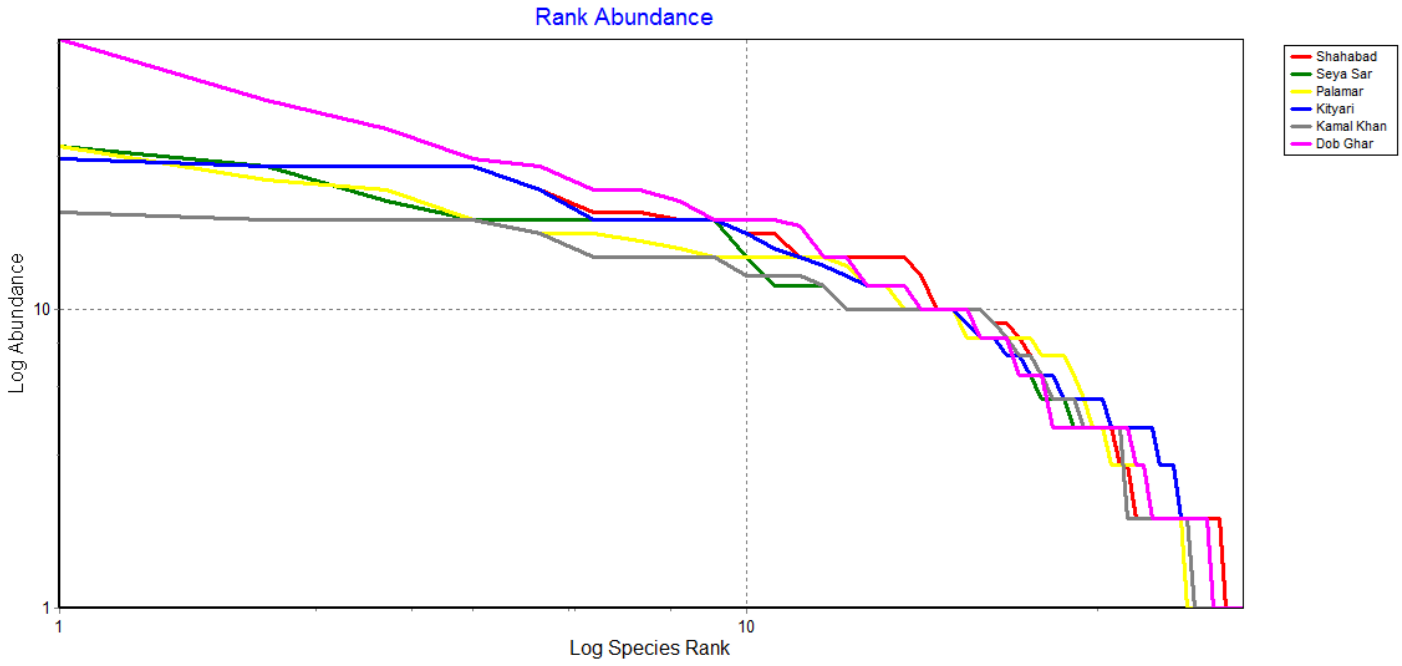

Figure 3

Rank abundance curve of bird relative abundance among six subtropical broadleaved evergreen urban forests

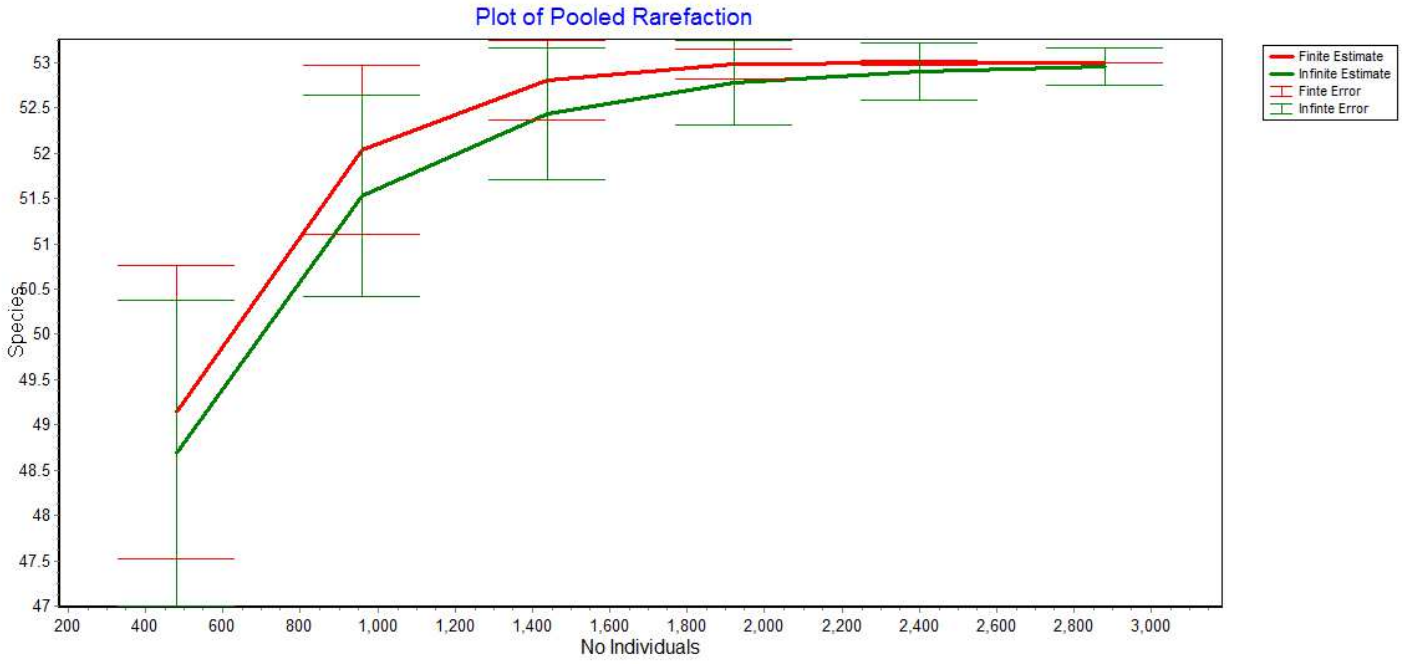

Figure 4

Comparisons of species richness (Pooled Rarefaction Plot) of bird communities in six subtropical broadleaved urban forests

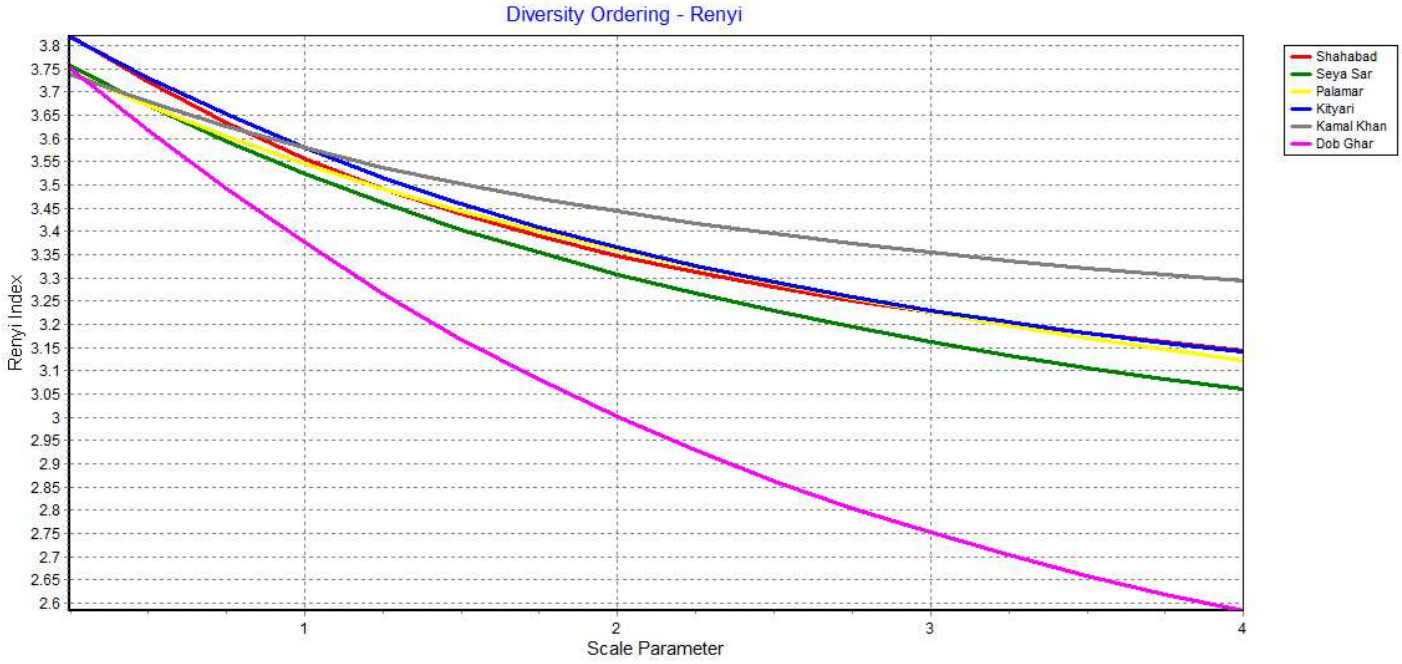

Figure 5

Comparison of relative diversity change (Diversity Ordering – Renyi) in six subtropical broadleaved urban forests

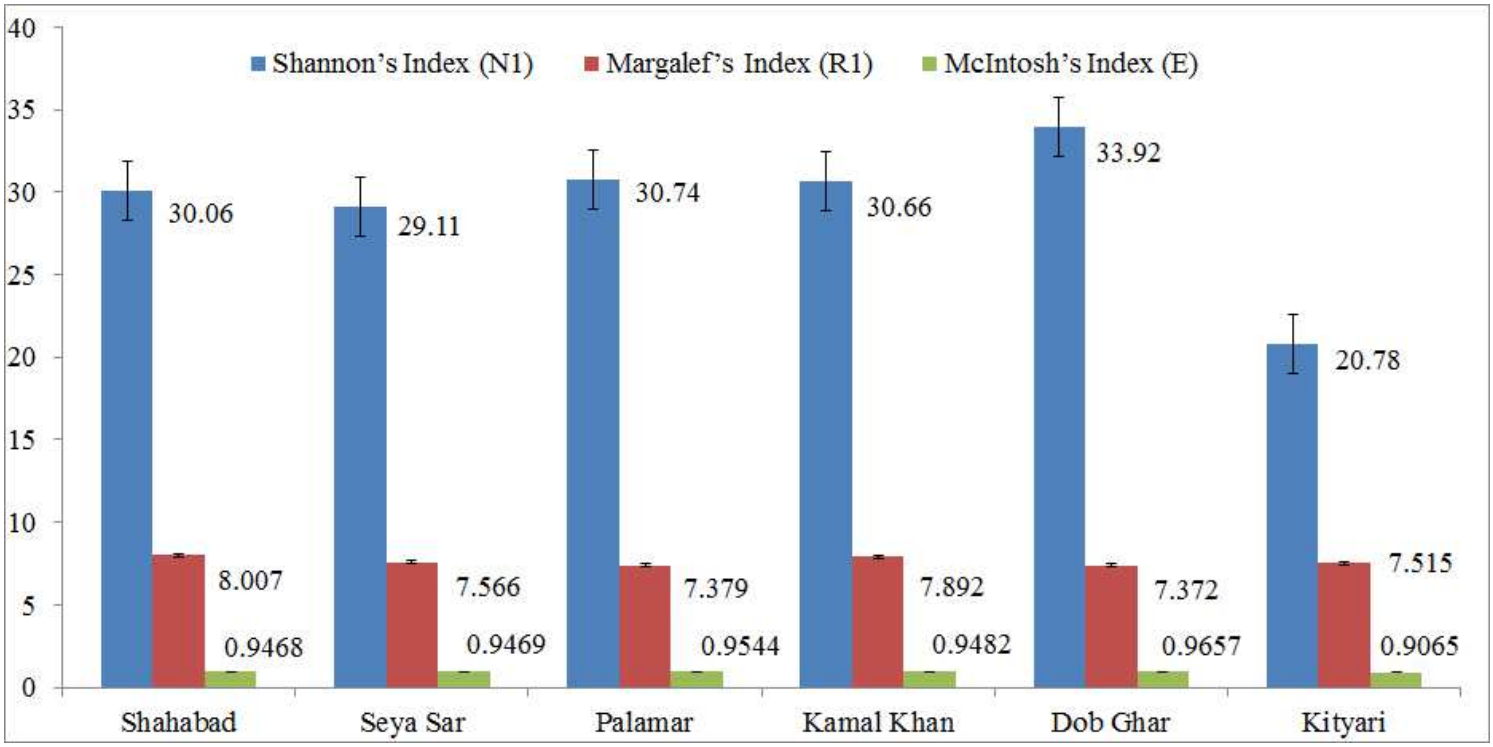

Figure 6

Comparison of diversity indices in six subtropical broadleaved urban forest habitats

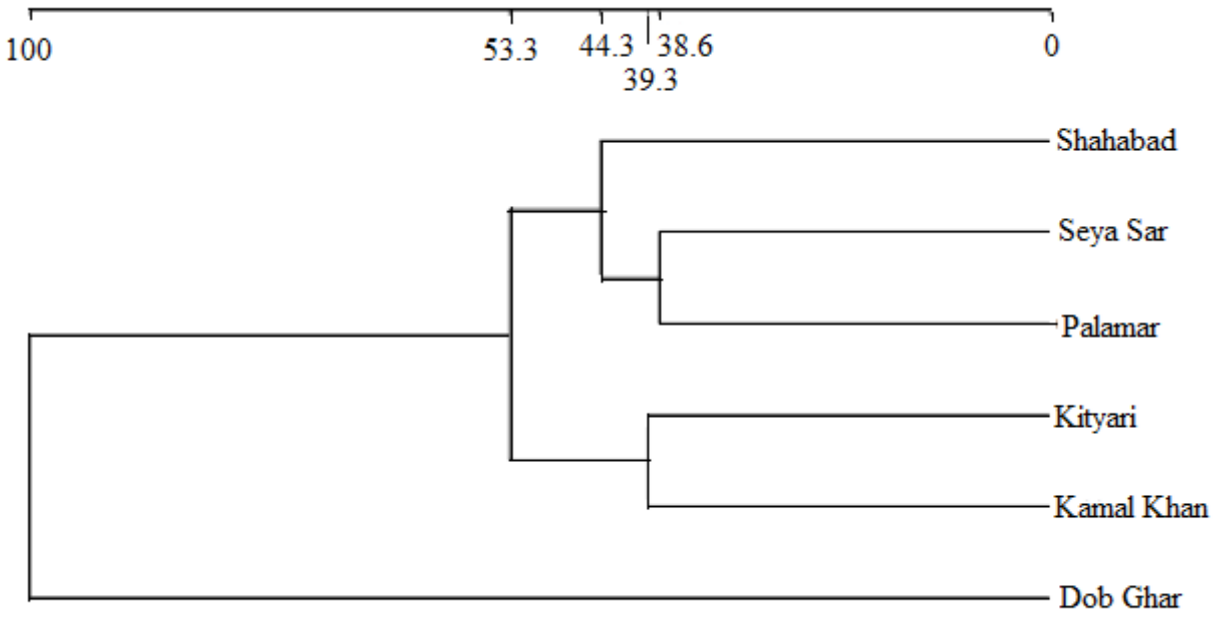

Figure 7

Dendrogram indicating bird diversity in six subtropical broadleaved urban forest habitats