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Habitat Use of Urban and Periurban Birds in a densely populated City of Eastern India

Bibhu Prasad Panda[1], Biswajita Mahapatra[1], Amrit Anjan Sahoo[2], Subhashree Sundar Ray[2], Siba Prasad Parida[3], Abanti Pradhan[1]*

[1]*Environmental Sciences, Dept. of Chemistry and BBRC, ITER, Siksha 'O' Anusandhan (Deemed to be University), Bhubaneswar - 751030, Odisha, India*
[2]*College of Forestry, Orissa University of Agriculture and Technology, Bhubaneswar- 751003, Odisha, India*
[3]*Dept.of Zoology, School of Applied Sciences, Centurion University of Technology and Management, Bhubaneswar- 752050, Odisha, India*

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ABSTRACT

The rapid growth in residential development in urban areas is the primary cause of habitat change that is affecting avian communities. Bhubaneswar is the capital city and the most urbanized area in state of Odisha, India. We have conducted avian surveys in 30 different sampling sites with 5 from each habitat type in the city. In total, we detected 222 species in 19 orders and 65 families. Agricultural areas were the most preferred habitat with over 52% of the total diversity followed by forest patches with 50%, parks and gardens 39%, wetlands 32%, grasslands 11% and human habitations 8%. Five species were globally nearly threatened, three vulnerable and one endangered according to the IUCN Red List. The cluster analysis shows that the avian community diversity shows positive correlation between forest patch and park and garden habitats ($r = 0.52$, $p < 0.05$), park and garden and human habitations habitats ($r = 0.29$, $p < 0.05$). Our findings describe high avian species richness as forest and wetland dwelling species are found in these urban habitats. Hence general conservation plan may be suggested to keep these species diversity and richness stable from being lessen.

Key words: Abundance, Bird Diversity, Species richness, Urban Habitats

INTRODUCTION

Conserving biodiversity in this urbanizing world has become a significant issue with the highly increasing human population. Various global environmental conventions suggested that conservation in urban areas is one of the innovative ways to conserve biodiversity (Khera & Sabata, 2009). Urban habitation covers nearly half of the world, thus we have to focus on urban biodiversity conservation to achieve all the levels of biodiversity (Satterthwaite, 2002). The medium-to-large forest patches inside the large human habitation represents a healthy urban area (Hartig & Cooper-Marcus, 2006). The native avian species diversity and richness varies according to the urbanization gradient and the amount of green space inside the city (Chiari *et al*., 2010). Adaptation is possible for non-native species to urban and suburban conditions when the urban habitats are highly modified (Mckinney, 2005). Wooded habitats in the urban areas are the most important variable for the diversity and richness of birds (Ferenc *et al*., 2016). Habitat heterogeneity, fragmentation, isolation and habitat loss can have negative impact on urban bird community (Marzluff & Ewing, 2001).

Native species can represent the core urban avifauna, but the rarer species should be saved from local extinction (Dale & Rowe, 2015). Various adverse factors like habitat fragmentation due to transport corridors, residential complexes and anthropogenic pressure like vehicular pollution, noise pollution and waste disposal are also affecting the biodiversity and ecosystem stability at large (Khera *et al*., 2009). Birds can be used to explore the effects of urbanization on biodiversity (Chace & Walsh, 2006). The urbanization gradient is the most important factor in restructuring the distribution pattern of the avian community (Croci *et al*., 2008). The results can describe the distribution pattern of different bird species and how they are affected by different microhabitats in the urban ecosystem. This should inform urban planners and policymakers about better urban design and ways to conserve urban biodiversity (Farmer & Shiroya, 2013).

The urban landscape of Bhubaneswar city has been growing rapidly in the last decades. In 2011, the major urban area or the municipal area of Bhubaneswar had a population of about 1.7 million covering area of 419 square kilometers (Anand & Deb, 2017). Many green patches exist inside the city in spite of growing urbanization, which provides good habitat for birds. The presence of green patches (Panda *et al*., 2016), Nandankanan Wildlife Sanctuary (Mohapatra *et al*., 2013; Mohapatra *et al*., 2018) and the Chandaka–Dampara Wildlife Sanctuary (Swain & Debata, 2018) in the outskirts of the city may also affect the avifaunal diversity and distribution (Mallik *et al*., 2015; Pattnaik *et al*., 2016; Kar and Debata, 2018). Our study aimed to understand the role of urban green patches in the conservation of avian diversity and to compare bird species richness and abundance among different urban habitats.

MATERIALS AND METHODS

Study area

Bhubaneswar city is the state capital of Odisha state and is the fastest growing city among all the declared smart cities by Govt. of India. The municipal area of this city

**Corresponding Author's E-mail: abantipradhan@soa.ac.in*

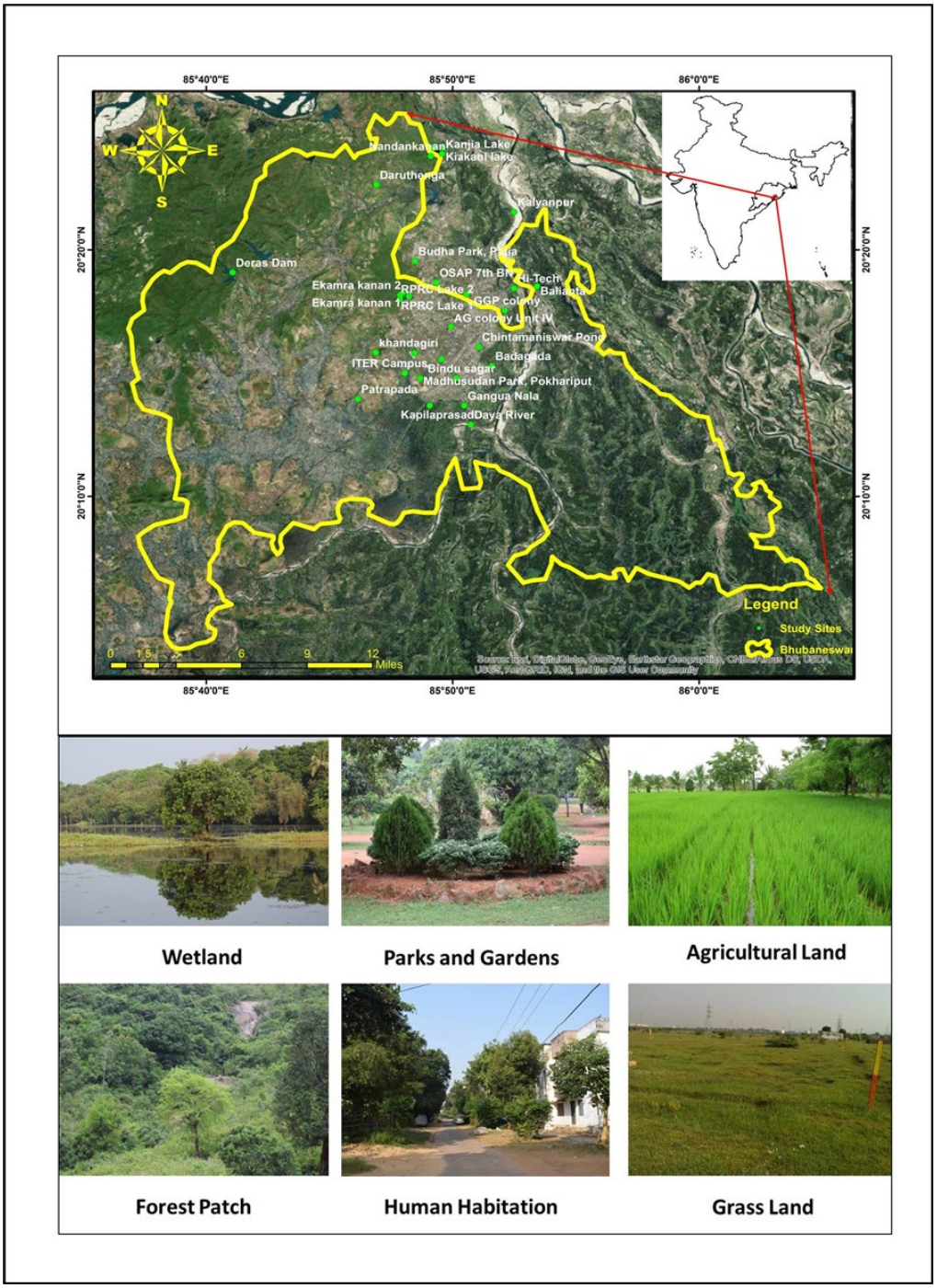

Figure 1. Map of the study area with sampling locations and photographs of all habits.

is approximately 419 km^2. The landscape of Bhubaneswar consists of various habitats such as urban forests to highly urbanized residential and commercial complexes. Besides the cityforest, there are many green spaces and parks that support the urban biodiversity (Nair, 2014). The city has two large lakes, many wetlands and the river Daya to the east of the city. Besides forest patches and wetlands, other habitats are human habitation, agricultural lands, grasslands and parks gardens. 5 sites were sampled in each of the six habitat types covering a total number of 30 sampling sites. The sampling habitats were like Grassland (GL) where the large grass fields are found with very less herbs and shrubs. The Wetland (WL) habitat covers the large water bodies and swampy area and the Forest Patches (FP) covers the dense woody vegetation with high density of trees. The Park and Garden (PG) habitat covers the scrublands and manmade gardens with human interference. The Agricultural Land (AL) describes the agricultural fields and various crop fields inside the city. The last habitat Human Habitation (HH) is the human dominated areas of different colonies and urban structures with high human disturbance (Figure 1).

Collection of data from different urban vegetation

Sampling was conducted from March 2016 to February 2017 at the 30 sites. Line transects and point count methods were used according to the suitability of the sampling sites. 100× 20 m line transects was used in green and woody vegetation like forest patches, park garden, human habitation and grassland. Distance point count technique (Bibby & Stuart, 1998) was used in wetland and agricultural land habitats. A Garmin GPS unit is used to record

the transect locations (Heather & Robertson, 2000). Surveys were conducted for 4 hours after sunrise and 2 hours before sunset in every month with 2-3 observers. Rainy or windy days were not suitable for surveys. This survey covered all seasons like summer (Mach – June), rainy (July – October) and Winter (November – February).

Data analysis

The birds recorded were classified into orders and families with habitat preference (WL, AL, PG, FP, HH, and GL) from their occurrence habitat. Abundance was considered as Common (C) if the number of individual was more than 30, Un-Common (U) if it's between 11-30 and Rare (R) if the number was less than 10. Residential status like Resident (Rs), Migratory (M) and Locally migratory (LM) was considered according to Grimmet, Inskipp and Inskipp (2014) and IUCN Red List status like Least Concerned (LC), Vulnerable (VU), Near Threatened (NT) and Endangered (EN) was from IUCN 2018. We calculated the following diversity indices for each habitat.

Shannon-Wiener species diversity index is

$$\bar{H} = -\sum_{i=1}^{s}\left(\frac{ni}{N} \times \ln\frac{ni}{N}\right)$$

where, *ni* represents the total number of individual species present in respective habitat and *N* represents the total number of species recorded in that respective habitat.

Index of dominance is

$$Id = \sum(ni\,(ni-1)/N(N-1)$$

where, ***ni*** is the number of individual in a particular site and N is the total number of species.

Richness index using Menhinick's equation is

$$D_{Men} = S/\sqrt{N}$$

where, S represents the total number of individual species present in respective habitat whereas N represents the total number of species recorded in that respective habitat.

Evenness index (Smith and Wilson's index) is $\bar{H}/\log_e S$, where, S represents the total number of individual species present in respective habitat (Shannon & Weiner, 1963; Magurran, 2004; Van Heezik *et al*., 2008).

For relative abundance analysis, we have summarized the number of bird species in each point and transect count and arrange them according to their respective taxonomic order. Then the total number of individuals present in each Order was divided with the total number of bird species recorded in all habitats.

The differences in bird composition bird species were analyzed by Bray-Curtis similarity index by using adonis function of vegan package (Oksanen, 2015) in R. The distribution of birds species across the habitats and the habitat preference of different species were analyzed by cluster analysis using matrix plot. The Pearson's correlation coefficient was calculated to determine the commonness of avian diversity among different urban habitats using corr-plot in the R version 3.4.4 (RStudio, 2013). The data matrix for cluster analysis consists of 6 habitats × 222 bird species. As our data is discretely distributed, we have applied the agglomerative method for cluster analysis. All the selected habitats were considered as dependent variables and the bird species occurrence within the corresponding habitat considered as the independent variable in the scatter plot analysis. In addition, all the data were estimated at α = 0.05 level of significance.

RESULTS

Bird surveys

A total number of 222 species were identified in 19 orders and 65 families. AL was the most used habitat with 52% (s = 115 species) of the total diversity followed by FP 50% (s = 111). PG habitat 39% (s = 87), the WL covers 32% (s = 70), GL covers 11% (s = 24) and HH covers 8% (s = 17).

Considering the abundance of the species during the study period, the number of sightings of the species considered as common and less number of sightings considered as rare. Being a high human-dominated area 42% (s=94) rare species are found where the common is 31% (s=68) and uncommon is 27% (s=60) (Figure 2). Most of the common birds were sighted in AL, FP, and PG (Figure 3). WL and FP had a higher number of rare species compared to all other habitats.

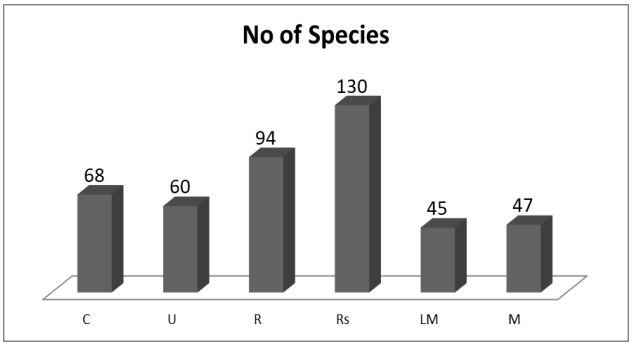

Figure 2. Distribution of bird species according to their occurrence [Common (C), Un-Common (U) and Rare (R)] and residential status [Resident (Rs), Migratory (M) and Locally migratory (LM)] in Bhubaneswar, Odisha, India.

Classification of species according to movement was 59% resident (s=130), by 21% migratory (s=47) and 20% local migratory (s=45) (Figure 2). Migratory species included one noteworthy record of the Indian Skimmer (*Rynchops albicollis*), found in WL habitat of Chandaka Wildlife Division. According to breeding status of birds, the resident birds mostly preferred the forest patch habitat among the urban vegetation. WL and AL habitats were preferred by most migratory birds. FP had the highest uniqueness and species richness among all other urban green spaces (Figure 4).

Among the 222 species, only one was endangered, the Black-bellied Tern (*Sterna acuticauda)* only recorded in WL. Three were Vulnerable: Pale-capped Pigeon (*Columba punicea*), mostly found in FP and PG habitat, Lesser Adjutant (*Leptoptilos javanicus)* in forest patches and Indian Skimmer (*Rynchops albicollis)*, generally restricted to WL habitat. We recorded Five Near Threatened species Black Headed Ibis (*Threskiornis melanocephalus)* in WL and GL habitat, Oriental Darter (*Anhinga melanogaster),* River Lapwing (*Vanellus duvaucelli)* and River Tern (*Sterna aurantia)* in WL habitat and Alexandrine Parakeet *(Psittacula eupatria)* in forest patches, agricultural land and also in Human habitations.

Bird species richness, diversity, and composition

We calculated different diversity indices (Table 1). The Shannon-Wiener diversity index was highest in AL, FP

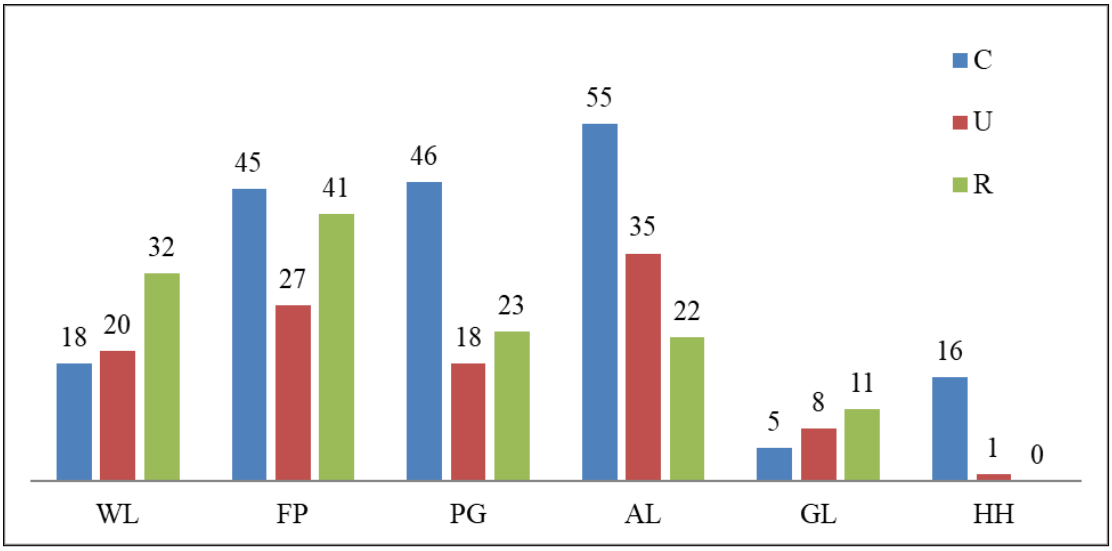

Figure 3. Distribution of Common, Uncommon and Rare species along with their respective habitats in Bhubaneswar, Odisha, India: Grassland (GL), Wetland (WL), Forest Patches (FP), Park and Garden (PG), Agricultural Land (AL), Human Habitation (HH).

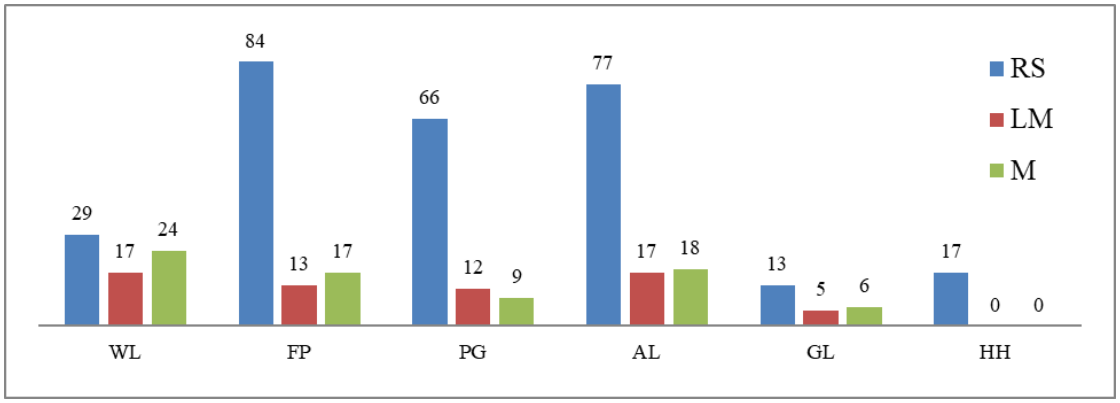

Figure 4. Distribution of Residence, Local Migratory and Migratory species along with their respective habitats in Bhubaneswar, Odisha, India: Grassland (GL), Wetland (WL), Forest Patches (FP), Park and Garden (PG), Agricultural Land (AL), Human Habitation (HH).

and PG, all the green spaces with 4.421, 4.415 and 4.173 respectively. FP, AL and PG had the highest species richness, while GL and HH habitats had relatively low species richness.

The Order Passeriformes showed the maximum diversity and relative abundance among the 19 Orders, in GL habitat (70.83%). Passerines also were the most common in FP, AL, PG, and HH. The order Charadriiformes showed a relative abundance of 31.42% in wetland habitat. Similarly Pelicaniformes and Cuculiformes show relative abundance of 20% and 17.65% in WL and HH, respectively. Falconiformes, Bucerotiformes, Suliformes, Ciconiiformes, Gruiformes, Caprimulgiformes and Galliformes showed the lowest abundance in AL and FP (Figure 5).

The relationship between avian species and urban vegetation

The best dendrogram model in (Figure 6) explained the similarity of the bird composition between six selected habitats. According to Bray-Curtis similarity index WL and GL had nearly equal diversity ($w_i = 0.15$, $p < 0.05$)

Table 1. Diversity indices of different urban gradients in Bhubaneswar, Odisha, India

Urban Habitats	Diversity Indices				
	Shannon-Wiener Diversity Index	Index of dominance	Richness Index	Evenness Index	Species Richness
WL	3.772	0.013	1.212	0.208	70
AL	4.415	0.028	1.393	0.256	111
FP	4.421	0.183	1.511	0.32	115
HH	2.615	0.008	0.816	0.034	17
PG	4.173	0.016	1.217	0.254	87
GL	2.693	0.013	1.195	0.054	24

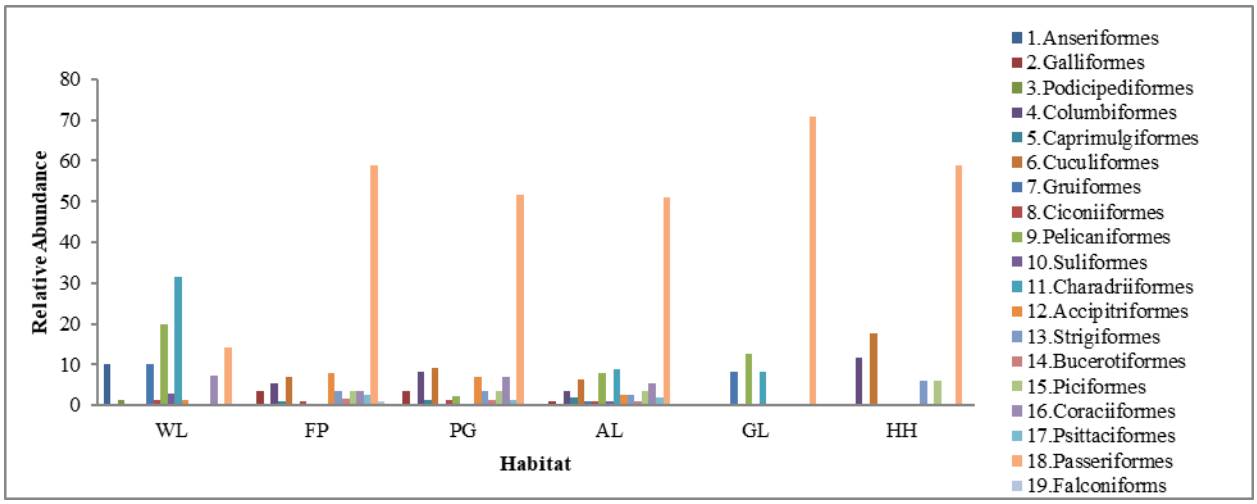

Figure 5. Relative abundances of bird species belong to different Orders across various urban habitats in Bhubaneswar, Odisha, India: Grassland (GL), Wetland (WL), Forest Patches (FP), Park and Garden (PG), Agricultural Land (AL), Human Habitation (HH).

because grasslands are nearer to the wetland area. Furthermore, FP and PG also have similar diversity (w_i= 0.75, $p < 0.05$) may be due to sharing the same tree species in the canopy. It also establishes the fidelity of the bird species in each site. The similarity index also depicts that the PG and HH habitat surrounded with high buildings and human habitations had the lowest similarity index i.e. (w_i = 0.11, $p < 0.05$). Here "w_i" represents the value of similarity index. House Sparrow (*Passer domesticus*), Rock Pigeon (*Columba livia*), Black Kite (*Milvus migrans*), Jungle Crow (*Corvus macrorhyncho*), Indian Pond Heron (*Ardeola grayii*), Asian Openbill Stork (*Anastomus oscitans*) and Little Cormorant (*Microcarbo niger*) were the most abundant species in almost all habitats.

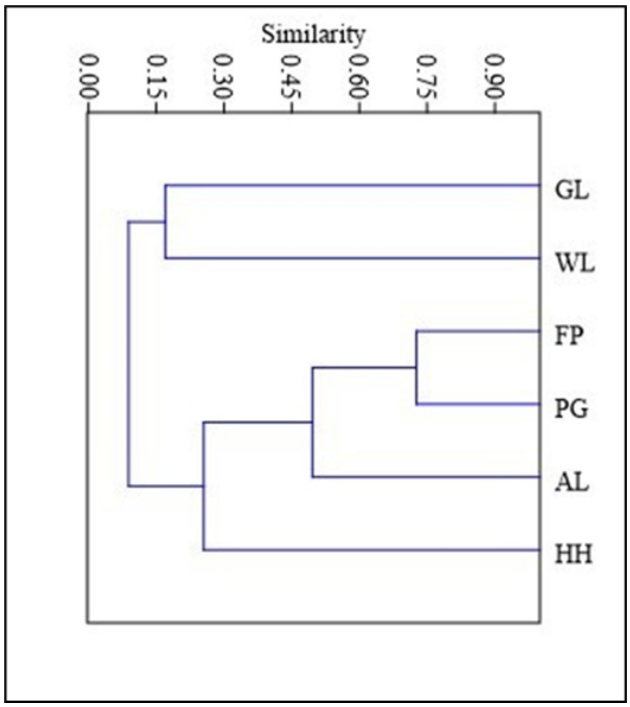

Figure 6. Bray-Curtis index showing the similarity of bird species composition among the different habitats in Bhubaneswar, Odisha, India: Grassland (GL), Wetland (WL), Forest Patches (FP), Park and Garden (PG), Agricultural Land (AL), Human Habitation (HH).

Cluster analysis shows that birds were homogenously distributed in six separate clusters of habitats (Figure 7). The habitats moderately to strongly correlated with species diversity and species composition in respective groups. In addition, the cluster analysis shows that avifauna was segregated along both axes, which depicts the four sites among the six selected urban habitats (FP, AL and PG and WL) were discretely distributed and had similar species composition except the GL and HH habitats. The species composition in FP and PG were more similar among all other habitats.

The habitat-habitat correlation is done by taking the species diversity as an independent variable and the habitats as the dependent variable. The avian community diversity of FP and PG habitats were highly correlated (r = 0.52, $p < 0.05$, Figure 8). FP was highly negatively correlated with the AL (r = - 0.66, $p < 0.05$). There was also a positive correlation between PG and HH habitats (r = 0.29, $p < 0.05$).

DISCUSSION

Considering the study site was a densely populated urban area, Bhubaneswar city contains a variety of habitats ranging from natural forests to highly artificial landscapes. We found the agricultural lands are the most suitable area for most of the birds. The richness was similar in forest patches and agricultural lands. Even though the population of the migratory and locally migratory species is less, but the sighting of these species describe the presence in these habitat. AL and WL need to be conserved to maintain urban biodiversity. The fragmented patches of forest and more numbers of riverine ecosystems along the urbanized landscape of Bhubaneswar city are influencing the avifaunal diversity.

As expected, this study confirmed that urban areas have relatively low avian diversity at all sampling sites. Urbanization has destroyed natural habitats, nesting sites and feeding behavior (Murgui, 2009; Njoroge *et al*., 2014; Kang *et al*., 2015; Leveau & Leveau, 2016). The semi-urban areas (AL, FP and PG) were more diverse than highly urbanized areas (HH). Urban areas were mostly dominated by urban exploiter species such as House Sparrow (*Passer domesticus*), Rock Pigeon (*Columba livia*), House Crow (*Corvus splendens*), Cattle Egret (*Bubulcus ibis*) and Black Drongo (*Dicrurus*

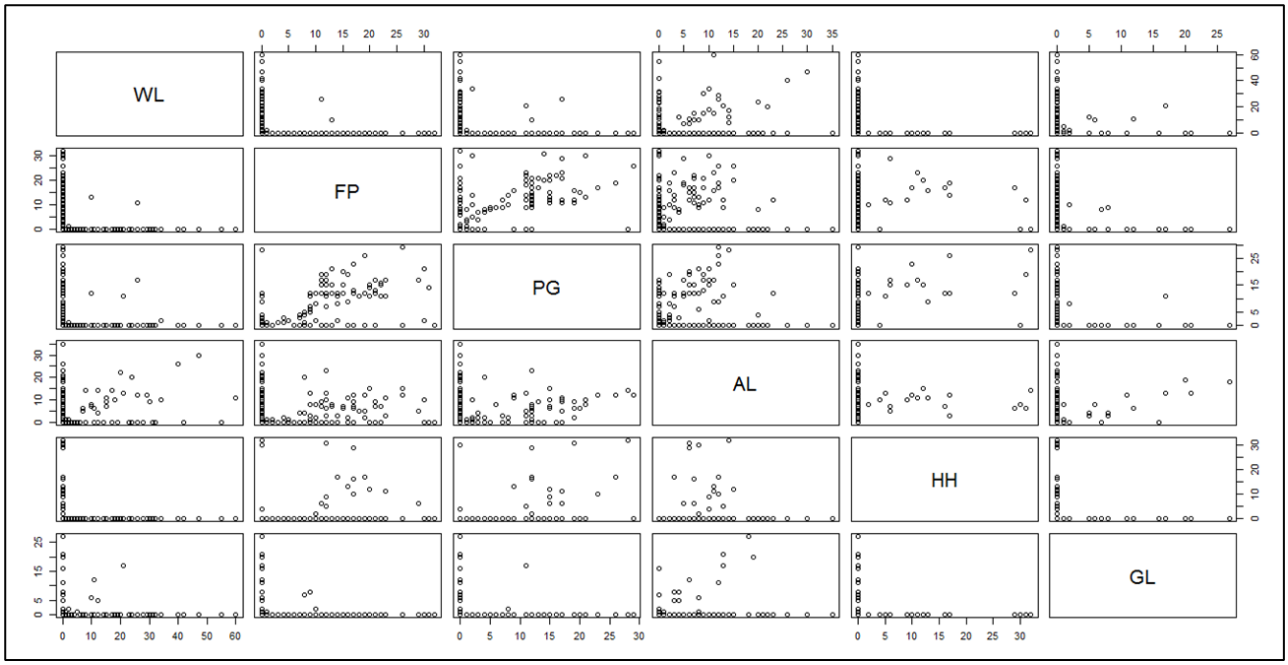

Figure 7. Cluster analysis (scatter plot matrices) showing the composition and habitat preference of the different avian species in Bhubaneswar, Odisha, India. Individual species occurrences in each habitat Grassland (GL), Wetland (WL), Forest Patches (FP), Park and Garden (PG), Agricultural Land (AL), Human Habitation (HH).

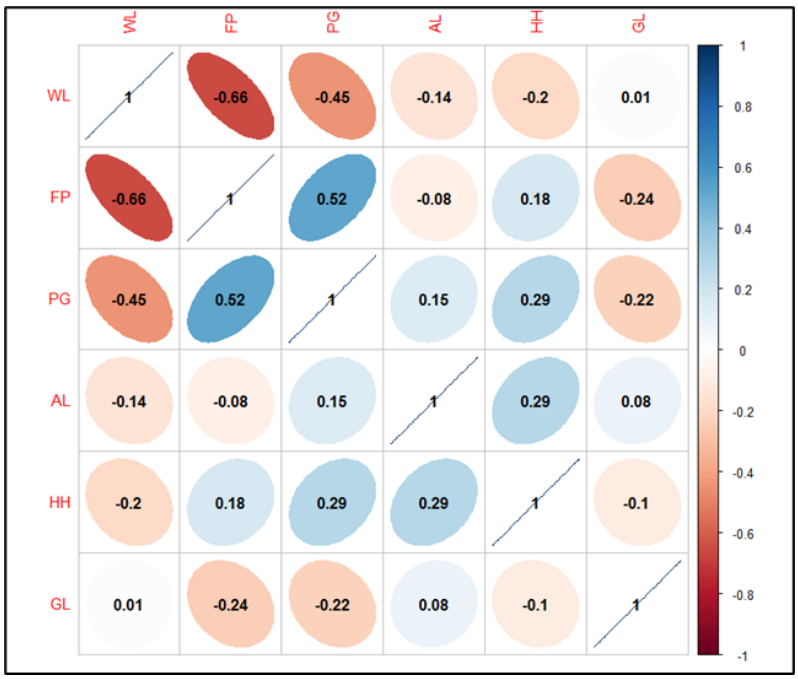

Figure 8. Corr-Plot showing correlations among Habitat-Species-abitat in the sampling habitats in Bhubaneswar, Odisha, India: Grassland (GL), Wetland (WL), Forest Patches (FP), Park and Garden (PG), Agricultural Land (AL), Human Habitation (HH).

macrocercus). These abundant species are found in all urban habitats (Khera *et al*., 2009; 2010).

Aurora *et al*. (2009) found that avian diversity in residential areas is related to house density, while diversity in natural habitat depends on the amount of woody vegetations. They suggested that a proper design for natural landscape inside residential areas could attract varieties of birds (Aurora *et al*., 2009). Belcher *et al*. (2018) also suggest that large buildings with roof, balcony and kitchen gardens attract more avian fauna into the city. In our study, the species diversity index shows that the fragmented forests and cultivated lands inside the city contribute the largest portion of the urban bird diversity. Negative factors like predation, poaching, habitat fragmentation and competition for food may increase the environmental bird refugees within the urban vegetation (Van Heezik *et al*., 2008).

Passeriformes had the highest species richness and relative abundance in agricultural areas. Species belonging to this order are generally insectivorous and granivorous, and therefore may find adequate food source in agricultural lands. Khera *et al*. (2009) found their study area in Delhi, India was primarily dominated by insectivore and omnivore species. While some studies compared the diversity of native and introduced bird species (Van Heezik *et al*., 2008) and rural and urban bird

diversity (Sengupta *et al*., 2014), they did not consider the contribution of food resources to species richness. Further in-depth studies are necessary to confirm the relationship between food, habitat preference and species diversity.

The reason behind the occurrence of 21 and 14 migratory species in WL and AL habitats, respectively may be the fact that the bird community consider these habitats suitable for shelter during migration (Martinez, 2014). We have to conserve those habitats inside the urban vegetation to increase the number of migratory bird species. A detailed study must be needed to know their habitat requirements, nesting pattern and also about their functional diversity. Sanesi *et al*. (2009) and Caula *et al*. (2014) observed that the amount of woodland in an urban matrix was directly proportional to the diversity of migratory species. Black-bellied Tern has undergone a moderately rapid decline due to continuously habitat loss, disturbances during the breeding season and breeding habitat, which has qualified as globally Vulnerable (IUCN, 2018). From our observation the GL and HH habitats need more conservation. As we described the positive correlation among PG, FP, and HH, we can make eco-friendly environment such as Park and gardens inside the urban residential areas. As a result, it will give a suitable, pristine environment for avian communities. Urbanization has been shown to leads to declines in bird diversity (Caula *et al*., 2014; Ferenc *et al*., 2016; Campbell-Arvai, 2018; Canedoli & Padoa-Schioppa, 2018). The results obtained from our study are consistent with previous studies.

The increasing human population, improper waste disposal activity, urban noise pollution, and over-raised wireless radiation are greatly affecting urban birds (Fontana & Magnusson, 2011). Despite these disturbances, the urban ecosystem also supports some rare species (Murgui, 2007). In spite of being a highly urbanized area with high anthropogenic pressure, Bhubaneswar city still contains a wide range of biodiversity (Panda *et al*., 2016). A conservation plan should be written for urban species to achieve habitat conservation by restore native vegetation cover and constructing artificial environment to sustain population of rare species (Fontana *et al*., 2011; Dale, 2018).In addition, remnant habitat of threatened species must be protected from urban development. Some research works are also going on the peripheral regions of the city for conservation of these rare species (Mallik *et al*., 2015; Debata *et al*., 2017; Kar & Debata, 2018; Kar *et al*., 2018; Mohapatra *et al*., 2019). By increasing public awareness, residents of Bhubaneswar will contribute to the conservation of floral and faunal diversity by creating open plantation in their land, planting shrubs and trees and by constructing metropolitan areas with a proper design for plantation. These initiatives should be implemented legally to protect urban avifauna.

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