Available online: www.notulaebiologicae.ro
Print ISSN 2067-3205; Electronic 2067-3264
Not Sci Biol, 2019, 11(4):421-427. DOI: 10.15835/nsb11410487
Original Article

Avifaunal Assemblage along Rural-Urban Gradients in Aligarh, Uttar Pradesh, India

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Abstract

Studies assessing the effect of urbanization on bird community structure largely carried out in developed countries and little is known about the developing region particularly in India. Bird diversity, richness, composition and guild structure was examined at urban, semi-urban, semi-rural and rural-natural sites in Aligarh, Uttar Pradesh. Each site was sampled using 90 fixed radius point counts between January and June 2016. Semi-urban site was more species rich (2.38 ± 0.06), diverse (0.80 ± .01) and even (0.90 ± .00) than other three urban-rural gradient sites. Density of bird peaked at urban site (43.09 ± 4.7). Numerically, urban site was dominated by omnivore species, which was replaced by insectivorous species at semi-natural, semi-rural and rural-natural sites. The current information corroborates the earlier studies assessing impact of urbanization of birds and Conell's intermediate disturbance hypothesis of higher richness and diversity at intermediate disturbance.

Keywords: bird community; diversity; feeding guild; richness; urbanization

Introduction

Urbanization- the conversion of an undeveloped to metropolis landscape or built up area is sprouting rapidly worldwide. The pace of urbanization is illustrated by the fact that urbanization of the world has increased from 44.7% in 1995 to 54% in 2015 at a rate of 0.9% (UN-Habitat, 2016). Sprawling urbanization coupled with resulting fragmentation decreases basic requirements of animals and isolate native species genetically and demographically (Ricketts, 2001). This extirpates native species (Blair, 1996; Chace and Walsh, 2006), alter the behavior of species in human modified areas (Magle and Angelon, 2011) and cause biotic homonization (McKinney, 2006).

Urbanization adversely impacts avifauna by decreasing natural food availability, nesting sites, influencing body condition, breeding success, nestling survival and increasing competition, stress, increasing bioaccumulation of pollutants and rate of mortality due to collision (Seress and Liker, 2015). A combination of these factors in urbanized area significantly influences species abundance, richness, diversity, biomass and composition (Blair, 1996; Blogger *et al*., 1997; Jokimaki *et al*., 2002; Chace and Walsh, 2006). Increasing urbanization typically increase biomass and density/abundance of bird (Chace and Walsh, 2006). Species richness and diversity either decline monotonously with increasing urbanization (Miller *et al*., 2003; Bhatt and Joshi, 2011; Sengupta *et al*., 2013; Sanz and Caula, 2014; Koparde and Raote, 2016; Leveau *et al*., 2017) or peaks at intermediate level of urbanization and then decreasing at higher levels (Jokimaki and Suhonen, 1996; Blair, 1996; Marzluff, 2001; Chace and Walsh, 2006; Graham and Duda, 2011). The latter trend is more ubiquitous though a recent study supported both the patterns (Lepczyk *et al*., 2008). Increasing urbanization causes synurbization of bird assemblage observed in many parts of the world (Beissinger and Osborne, 1983; Sengupta *et al*., 2013; Pal *et al*., 2019). An urbanized area attracts "*urban exploiter/adapters*", more natural supports "*urban avoiders/intolerant*" and a ecotone between the two to "*suburban adaptable*" (Blair, 1996). However, most of our knowledge on effect of urbanization stems from studies in developed countries and little is known about the developing region despite the burgeoning urbanization.

India supports around 1300 species of avifauna accounting 13% of the world (Grimmet *et al*., 1998). Though India has experienced a rapid urbanization; 26.6% to 37%, between 1995 and 2015 (UN-Habitat, 2016), yet only scarce evidences existed on the effect of urbanization, restricted to some biogeographic zones such as Himalaya (Bhatt and Joshi, 2011; Naithani and Bhatt, 2012), coast (Sengupta *et al*., 2013; Kale *et al*., 2018) and Deccan plateau (Pal *et al*., 2019) and none in Gangetic plains. To fill the

Received: 17 Apr 2019. Received in revised form: 13 Dec 2019. Accepted: 21 Dec 2019. Published online: 24 Dec 2019.

knowledge gap about effect of urbanization, present study is an attempt to investigate pattern of richness, diversity, and evenness, density along with functional diversity, dominant feeding guilds and species restricted at various urban-rural gradient sites in Aligarh, Uttar Pradesh.

Materials and Methods

Study area

Aligarh district (27° 29' N to 28° 1' N latitude and 77° 29' E to 79° 40' E longitude) in north Indian state of Uttar Pradesh, India, encompasses an area of 3650 sq. km between two perennial rivers of Himalayan origin viz. the Ganga and Yamuna. Aligarh is characterized by monsoonal type of climate with three distinct seasons; winter (November to February), summer (late March to June), monsoons or rainy season, (July to October). During winters temperature drops down to 10 °C during night which rises up to a maximum of 44 °C during summers. The district is densely populated (1,007 person/sq. km) with a total population of 36,73,889 persons (Census of India, 2011). Four sampling sites representing typical form of urban (163.5 ha), semi-urban (208.22 ha), semi-rural (165.13 ha) and rural-natural (159.13 ha) were selected based on increasing built up area and decreasing natural vegetation cover (Table 1, Figs. 1-2).

Methodology

Sampling of birds at each rural-urban gradient site was conducted through 30 m closed width point count method between January and June 2016. Each point count lasted for 15 min during which bird species were recorded along with their numbers. A total 90 point count stations were established randomly maintaining a minimum interval of 250-300 m at each site. Sampling locations were decided according to the visibility and accessibility. Birds were sampled three times at each point station periodically. Bird species were classified into various dietary guilds viz. carnivore, frugivore, omnivore, insectivore, granivore, piscivore and nectivore following Ali and Ripley (1987).

The species encountered during all sampling point were added cumulatively to determine the total number of species for each sampling sites. Density of bird was calculated by dividing total bird encounter at a point by the area covered. Bird richness (Margalef's), diversity (Shannon's diversity) and evenness were calculated using PAST 3.0. The abundance each of bird species was assessed on an arbitrary frequency scale as per the following categories: rare = 1-5 sightings, common = 6-25 sightings, abundant = 26-50 sighting, very abundant = >50 sightings. The difference in mean density, diversity, richness and evenness across the various urban gradient sites was verified through One-way Analysis of variance (ANOVA) in SPSS ver. 20.0. Frequency of sighting among various sampling sites was compared using Chi-square test.

Results

A total 63 species were observed at various rural-urban gradient sites representing 14 orders and 39 families. Richness of avifauna was maximum (2.38 ± .06) at semi-urban site and minimum (1.08 ± .05) at urban site (Table 2). Bird richness varied significantly across the study sites ($F_{3, 397}$ = 84.89, P<0.01). Semi-urban site was found to be more diverse (0.80 ± .01) than rural-natural and semi-rural sites (0.74 ± .01 each). Diversity of birds also varied significantly among all four sites ($F_{3, 397}$ = 86.65, P<0.01). The distribution of bird species were more even at semi-urban site (0.90 ± .00) compared with other three sites (Table 2). Urban site supported highest density of birds (43.09 ± 4.7 birds/hectare) while rural-natural site to minimum, with a value of 30.77 ± 2.4 individuals of birds per hectare (Table 2). However, density of birds across various rural-urban gradient sites was not statistically significant.

Of the 63 species encountered, 21 species (33.3%) and 12 species (19.0%) showed a exclusive distribution reported from four and one sampling site respectively (Table 3). Among the exclusively occurring species, eight (66.6%) were found at rural-natural site and four species (33.3%) occurred at semi-rural site only (Table 3). Two species were very abundant at urban site: rock pigeon (*Columba livia*) and laughing dove *(Spilopelia senegalensis)*. Semi-urban site was numerically dominated by rose-ringed parakeet (*Psittacula krameri*), common myna (*Acridotheres tristis*),

Table 1. Description of various urban-rural gradient sites in Aligarh, Uttar Pradesh, India

Sampling sites	Locality	Description
Urban (163.58 ha)	Aligarh city enclosing Rasalgunj, Railway road, Upper court, Gandhi Nagar (27°53'14.42" N & 78° 4'0.73" E)	These areas were a part of the old city converted into human habitation more than a century ago and are devoid of natural vegetation except a few trees such as *Ficus religiosa, Ficus infectora, Azaradiracta indica, Delonex regia, Zizypus mauritiana.* This site was dominated by built up (138.13 ha), few area under lawns (7.92ha) and natural vegetation (17.52 ha).
Semi- Urban (208.22 ha)	Aligarh Muslim University campus and Naqvi Park (27°54'48.14" N & 78° 4'32.81" E)	These area were characterized by built up area (84.30 ha) along with patches of lawns (29.23ha) and tree cover (94.69ha) representing indigenous floral elements such as *Bougainvillea glabra, Polyathia longifolia, Holoptelea integrifolia, Azadirachta indica, Bauhinia purpurea, Firmiana simplex Melia azedarack, Grevillea rubusta, Terminalia arjuna, Delonix regia, Ficus drupaceae, Ficus rumphi, Sterculia alata, Dalbergia sissoo.*
Semi-rural (165.13 ha)	Sagar complex (27°56'46.15" N & 78° 4'56.34" E)	Recently developing area where high construction was in progress. This site possesses some natural floral elements (17.52ha) along with cultivated area (9.17 ha) as the area has recently come under human habitation (79.34 ha).
Rural-Natural (159.13 ha)	Chherrat villages and Heinz Pvt. Ltd. (27°57'19.39" N & 78° 5'41.19" E)	This site was characterized by largely croplands (62.65 ha), a large patch of natural vegetation dominated by *Prosopis juliflora (*66.61 ha) and village (19.98 ha).

The area of each class was evaluated by digitizing the land cover classes on Google Earth pro.

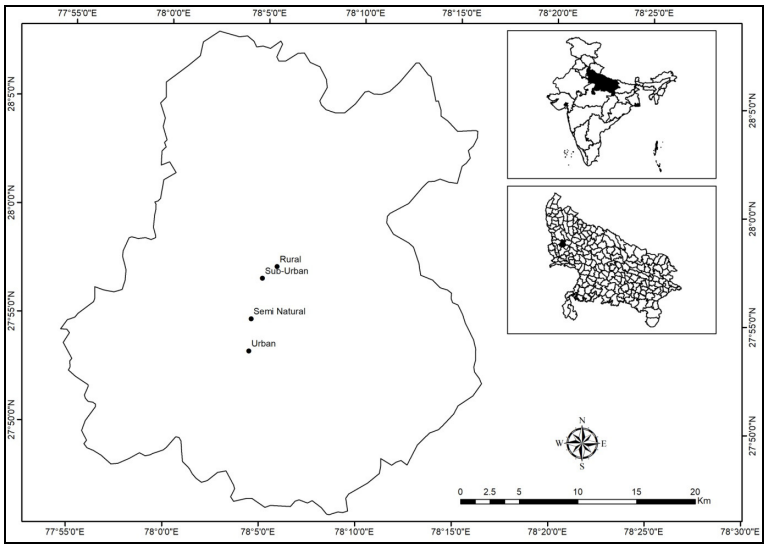

Fig. 1. Bird sampling sites in Aligarh district, Uttar Pradesh, India

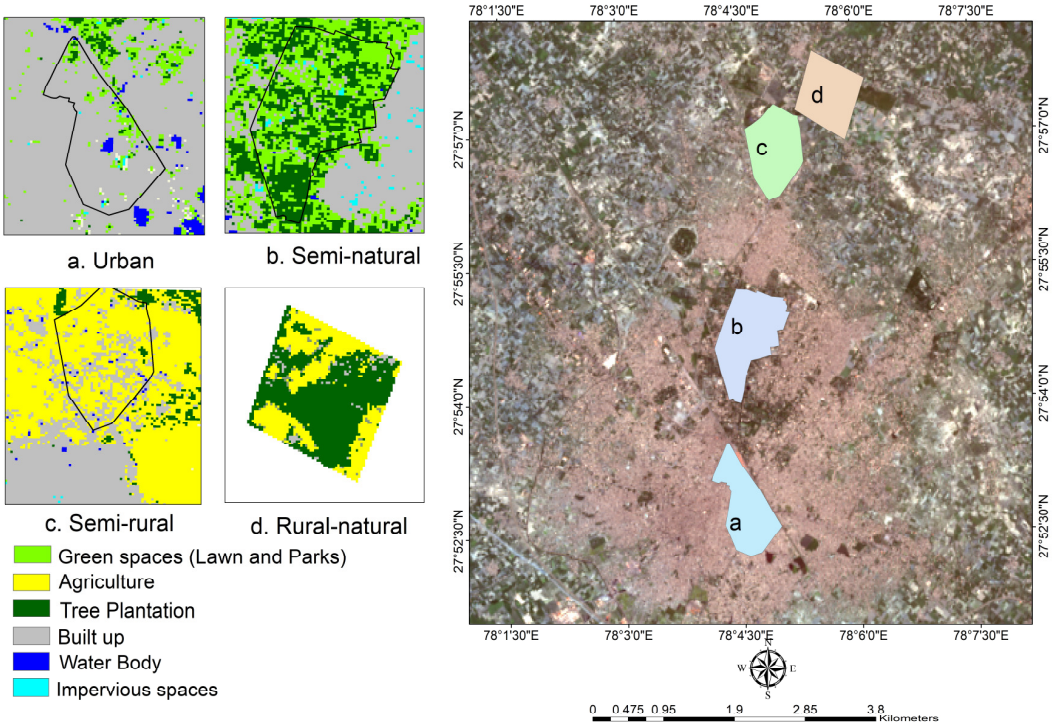

Fig. 2. Study sites in Aligarh, Uttar Pradesh, India a) Urban, b) Semi-urban c) Semi-rural d) Rural-natural

house crow (*Corvus splendens*), Eurasian collard dove *(Streptopelia decaocto)*, jungle babbler *(Turdoides striata)* and black kite (*Milvus migrans*). Laughing dove, rock pigeon, house crow and Asian pied starling *(Gracupica contra)* was found very abundant at rural-natural site again. The sighting frequency of most of the species of birds was significantly different across the urban gradient sites except few rarely sighted species (Table 3).

Bird species from seven guilds were observed with six feeding guilds present at three sites i.e. urban, semi-natural and semi-rural. Species of nectivorous guild were recorded from rural site only. Urban site was found to be numerically dominated by omnivore species which was replaced by insectivore species at other three urban-rural gradient sites. Semi-urban and semi-rural site had almost similar guild composition. At both the site, dominant guild was insectivore which was followed by omnivore (Fig. 3). However, the dominant guild; insectivores, was followed by piscivorous guild at rural site. Very few omnivore species occurred at rural site (Fig. 3).

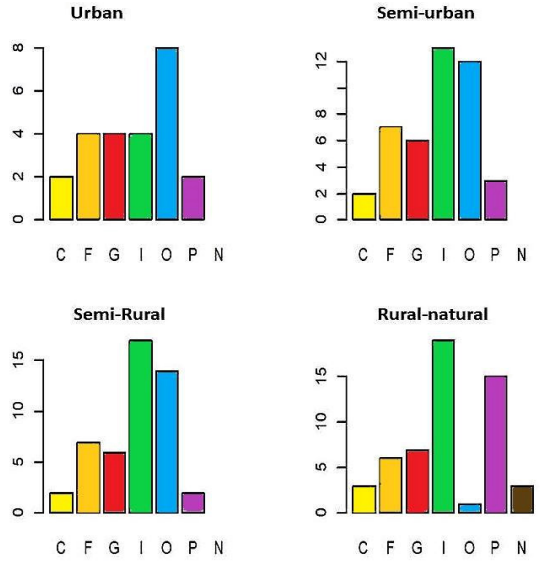

Fig. 3. Feeding guild of birds along rural-urban gradients sites in Aligarh, Uttar Pradesh (C=Carnivore, F=Frugivore, G=Granivore, I= Insectivore, N= Nectivore, O=Omnivore, P=Piscivore)

Table 2. Bird community structure at various sampling sites in Aligarh, Uttar Pradesh, India

Sampling sites	Families	Species	Density (Birds/hectare)	Richness	Diversity	Evenness
Urban	17	24	43.09 ± 4.7	1.08 ± .05	0.43 ± .02	0.72 ± .02
Semi- Urban	28	43	36.16 ± 3.3	2.38 ± .06	0.80 ± .01	0.90 ± .00
Semi-rural	35	48	37.27 ± 4.5	2.18 ± .06	0.74 ± .01	0.87 ± .01
Rural-natural	34	55	30.77 ± 2.4	2.22 ± .06	0.74 ± .01	0.87 ± .01
Overall	39	63	36.82 ± 1.9	1.99 ± .04	0.69 ± .01	0.84 ± .00

Table 3. Frequency of sighting of bird species at various urban gradient sites in Aligarh, Uttar Pradesh, India

Species	Urban	Semi urban	Semi-rural	Rural-natural	Chi-Square (P value)
Ashy Prinia (*Prinia socialis*)	3	6	13	18	<0.01
Asian Koel *(Eudynamys scolopaceus)*	2	30	7	15	<0.01
Asian Paradise Flycatcher *(Terpsiphone paradise)*	0	0	0	1	NA
Asian pied Starling *(Gracupica contra)*	0	22	55	23	<0.01
Bank Myna *(Acridotheres ginginianus)*	6	0	30	14	<0.01
Bay-backed Shrike *(Lanius vittatus)*	0	2	1	0	NA
Black Drongo *(Dicrurus macrocercus)*	0	30	36	17	<0.01
Black Kite *(Milvus migrans)*	21	50	18	16	<0.01
Black -winged Stilt (*Himantopus himantopus*)	0	0	2	1	NA
Brahminy Starling *(Sturnia pagodarum)*	0	1	2	1	NA
Brown-headed Barbet *(Megalaima zeylanica)*	2	19	5	8	<0.01
Brown rock Chat *(Cercomela fusca)*	37	3	44	8	<0.01
Cattle Egret *(Bubulcus ibis)*	1	6	6	12	<0.05
Chestnut -shoulderd Petronia *(Petronia superciliaris)*	0	0	1	0	NA
Common Hoopoe *(Upupa epops)*	0	0	5	4	NA
Common Moorhen *(Gallinula chloropus)*	0	2	0	3	NA
Common Myna *(Acridotheres tristis)*	24	73	25	46	<0.01
Common Sandpiper *(Actitis hypoleucos)*	0	0	2	1	0
Common Tailorbird *(Orthotomus sutorius)*	0	0	0	6	<0.01
Coppersmith Barbet *(Megalaima haemacephala)*	0	5	5	1	NA
Egyptian Vulture (*Neophron* percnopterus)	0	0	0	1	NA
Eurasian collard Dove *(Streptopelia decaocto)*	15	54	42	44	<0.01
Indian Thick-knee *(Burhinus indicus)*	0	0	0	1	NA
Greater Coucal *(Centropus sinensis)*	0	6	6	10	<0.05

Green Bee-eater *(Merops orientalis)*	0	0	16	23	<0.01
Grey Francolin *(Francolinus pondicerianus)*	0	0	0	10	<0.01
Grey Hornbill *(Ocyceros birostris)*	3	24	4	12	<0.01
House Crow *(Corvus splendens)*	13	65	58	44	<0.01
House Sparrow *(Passer domesticus)*	18	3	16	4	<0.01
House Swift *(Apus nipalensis)*	10	1	2	0	<0.01
Indian bush Lark *(Mirafra erythroptera)*	0	0	5	0	<0.01
Indian golden Oriole *(Oriolus oriolus)*	0	1	2	0	NA
Indian Jungle Crow *(Corvus macrorhynchos)*	1	7	1	9	<0.01
Indian Peafowl *(Pavo cristatus)*	0	11	3	35	<0.01
Indian Robin *(Saxicoloides fulicatus)*	0	7	19	7	<0.01
Indian Roller *(Coracias benghalensis)*	0	1	3	0	NA
Indian Silverbill *(Lonchura malabarica)*	0	2	16	9	<0.01
Jungle Babbler *(Turdoides striata)*	1	51	8	44	<0.01
Large grey Babbler *(Turdoides malcolmi)*	0	0	12	31	<0.01
Laughing Dove *(Spilopelia senegalensis)*	55	44	68	39	0.05
Oriental Magpie-robin *(Copsychus saularis)*	0	14	2	1	<0.01
Paddy field Pipit *(Anthus rufulus)*	0	0	4	0	<0.01
Plain Martin (*Riparia paludicola*)	0	0	1	0	NA
Plain Prinia *(Prinia inornata)*	0	0	4	3	NA
Indian pond Heron *(Ardeola grayii)*	0	2	0	7	<0.01
Purple Sunbird *(Nectarinia asiatica)*	2	15	8	7	0.05
Red-headed Bunting *(Emberiza bruniceps)*	0	0	0	1	NA
Red-naped Ibis *(Pseudibis papillosa)*	0	0	0	1	NA
Red-vented Bulbul *(Pycnonotus cafer)*	14	47	43	28	<0.01
Red-wattled Lapwing *(Venellus indicus)*	0	7	20	20	<0.01
Rock Pigeon *(Columba livia)*	81	45	62	50	<0.01
Rofous Tree Pie *(Dendrocitta vagabunda)*	0	12	2	5	<0.01
Rose-ringed Parakeet *(Psittacula Krameri)*	27	74	17	36	<0.01
Scaly-breasted Munia *(Lonchura punctulata)*	0	0	0	1	NA
Shikra *(Accipiter badius)*	2	2	1	4	NA
Spotted Dove *(Spilopelia chinensis)*	0	1	0	2	NA
Spotted Owlet *(Athene brama)*	0	1	0	1	NA
White-breasted Waterhen *(Amaurornis phoenicurus)*	0	3	0	7	<0.01
White-naped Woodpecker *(Chrysocolaptes festivus)*	0	1	0	2	NA
White-throated Kingfisher *(Halcyon smyrnensis)*	2	4	13	13	<0.01
White Wagtail *(Motacilla alba)*	0	2	1	2	NA
Wire-tailed Swallow *(Hirundo smithii)*	1	0	0	1	NA
Yellow-footed Green Pigeon *(Treron phoenicoptera)*	1	37	7	9	<0.01

Discussion

The current study concludes that avifaunal richness, diversity and composition are influenced by urbanization in Aligarh district as well consistent with the previous studies in India (Naithani and Bhatt, 2012; Sengupta *et al*., 2014; Kale *et al*., 2018; Pal *et al*., 2019). The low richness and diversity of birds in urban area as compared to the semi-urban, semi-rural and rural-natural is in line with earlier studies across the globe (Blair, 1996; Marzluff, 2001; McKinney, 2002; Pauchard *et al*., 2006; McKinney, 2008; Garaffa *et al*., 2009; Naithani and Bhatt, 2012; Sengupta *et al*., 2013; Pal *et al*., 2019). Moreover, the high bird species diversity and richness at semi-urban site supported Conell's intermediate disturbance hypothesis (Conell, 1978) in line with Pal *et al*. (2019) in India and outside (Jokimaki and Suhonen, 1993; Marzluff, 2005). This however, contradicts Kale *et al*. (2018); results of that study supported Gray's increasing disturbance hypothesis in Amravati, central India. The higher diversity of birds in semi-urban site could be related to higher habitat heterogeneity at semi-natural site. Our semi-urban site, having well-established ground, shrub cover, canopy cover along with concrete structure; would be expected to provide the more foraging, nesting and shelter opportunities for a range of species that urban site. Many studies have highlighted heterogeneous landscape provides more niches to exploit and hence supports high diversity (Bohning-Gaese, 1997; Fahrig *et al*., 2011; Bonilla *et al*., 2012; Katayama *et al*., 2014). Consistent with earlier studies in India (Kale *et al*., 2018; Pal *et al*., 2019) and outside as well (Chace and Walsh, 2006 and references therein), the high density of birds in urban

area supported resource concentration hypothesis (Pickett *et al*., 2001).

Bird species composition was found different among the various urban-rural gradient sites. Some bird species viz. Asian paradise flycatcher *(Terpsiphone paradise)*, Indian thick-knee *(Burhinus indicus)*, red-headed Bunting *(Emberiza bruniceps)*, red-naped ibis *(Pseudibis papillosa)*, scaly-breasted munia *(Lonchura punctulata)*, common tailorbird *(Orthotomus sutorius)* and Egyptian vulture (*Neophron percnopterus*) were restricted to rural site only. Restricted distribution of these species could be related to their habitat association. Asian paradise flycatcher is summer visitor to northern India and inhabits wooded areas and secondary forest. Eurasian thick-knee is a bird of dry scrub, stony dry riverbeds with scrub. Red-naped ibis prefer freshwater marshes and large lakes, flooded grassland and paddy-field. Tall wet grassland, reedy marshes, sugarcane field and scrub near cultivation are home of scaly-breasted munia (Grimmet *et al*., 2015). Increasing vegetation cover increases the probability of having a breeding site of Egyptian vulture while decreases with increasing urbanized surface area (Sara and Vittorio, 2003). Urban, semi-urban and semi-rural sites in Aligarh district lack these habitat, hence cause of their restricted distribution. Chestnut-shoulder petronia *(Petronia superciliaris)*, Indian bush lark *(Mirafra erythroptera)*, paddy field pipit *(Anthus rufulus)* and plain martin occurred at semi-rural site only. Chestnut-shoulder petronia (*Gymnoris xanthocollis*) inhabits thorn scrub trees at edges of cultivation. Indian bushlark is a bird of stony scrub and fallow cultivation. Paddy field pipit (*Anthus rufulus*) resides in short grassland and Plain martin around rivers and lakes (Grimmet *et al*., 2015). Semi-rural supports these habitats; hence correspond to their restricted distribution.

The high abundance of rock pigeon and laughing dove in urban landscape is in accordance with the previous studies highlighting higher abundance of synanthropic/urban adaptors species in urban landscape (Blair, 1996; Jokimaki *et al*., 2002; Bhatt and Joshi, 2011). Granivore species are benefitted by public housing as these estates contain anthropogenic food which could support their higher abundance (Lim and Sodhi, 2004). It is important to note that a synanthropic species i.e. house sparrow (*Passer domesticus*) was not abundant at urban site implying decline of this species as many urban habitats around the world (Summers-Smith, 2007; Joshi and Bhatt, 2011; Mondak, 2017).

There is a clear distinction between urban and rural-natural sites in terms of various feeding guild. Urban site was dominated by omnivore guild whereas insectivore guild dominated the semi-urban, semi-rural and rural-natural site. Dominancy of omnivore species at urban site has also been observed by Beissinger and Osborne (1982), Sengupta *et al*. (2014) and Pal *et al*. (2019). It could be related with higher house density in comparison with other urban-rural gradients sites as reported by Sengupta *et al*. (2014). Number of insect eating birds increases from urban to rural-natural site. Other studies have also found that insectivores were more abundant in rural habitats (Kark *et al*., 2007; Conole and Kirkpatrick, 2011) and the proportion decreased with increasing percentage of built up area (Lim and Sodhi, 2004). Furthermore, insectivores are sensitive to environmental quality (Clergeau *et al*., 1998) and insufficient vegetation (Beissinger and Osborne, 1982) and hence, their preponderance could be attributed to higher resource availability, e.g. trees and open areas (Lim and Sodhi, 2004) at semi-urban, semi-rural and rural-natural compared to urban site. The occurrence of bird from nectivorous guild at rural site only might be due to the flowering plant species.

Conclusions

Urban site supports low richness and diversity of birds than other urbanization gradient sites. Richness and diversity of avifauna reaches its peak at semi-natural site. Urban site was found to be dominated by omnivore guild which was replaced by insectivore guild at other urbanization gradient sites. The present study supports intermediate disturbance hypothesis of higher bird richness and diversity at moderate disturbance.

Acknowledgements

The first author is thankful to Mr. Shiraj Majoomdar and Mr. Rohit Chaudhary for rendering their help during the field work. This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Conflict of Interest

The authors declare that there are no conflicts of interest related to this article.

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