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Species diversity, distribution and habitat utilization of urban wildlife in a megacity of Bangladesh

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ABSTRACT Urban environments harbour many species of wildlife. Such environments may provide a wide range of benefits, although these species could also face more threats in them than outside of the cities, without proper consideration. A comprehensive study of the wildlife in Dhaka, a megacity of Bangladesh, was conducted from September 2015 to November 2018 at eleven sites to estimate the extent of their presence. We collected data following transect line surveys for birds and mammals, and visual encounter surveys for herpetofauna. A total of 209 species belonging to 79 families of wildlife were recorded: 12 amphibians, 19 reptiles, 162 birds and 16 mammals. This study recorded a total of 13,805 individuals: 12,183 birds, 872 mammals, 605 amphibians, and 145 reptiles. In Shahbag site in total 3,039 individuals of wildlife were counted followed by Ramna (2,576), Uttara (2,108) and Mirpur (1,872). Seventeen species were shared between habitats and an average 33% of the total species were shared between sites (range 13–52%). Slightly more than half of the wildlife was recorded on trees, followed by grasslands and urban settlements. We identified some anthropogenic activities such as pollution, rapid construction work, random vehicle movements, using parks and gardens as a short passageway that may have a negative effect on urban wildlife distribution and survivability. Our baseline data on vertebrate wildlife diversity indicate that urban green patches in the study sites may contribute to maintain and conserve biodiversity in the megacities. We hope that the results of this baseline data on wildlife diversity will be valuable to urban decision makers for the development and implementation of more informed megacity master plans. Wildlife diversity in such areas can be significant and without proper planning, can be affected by unchecked human activities in urban settings.

KEY WORDS Habitat utilization; Species richness; Urban wildlife; Wildlife diversity.

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INTRODUCTION

Urbanization is seemingly the most prominent anthropogenic transformation that the ecological system experiences these days across the world (Rocha & Fellowes, 2018). These human transformations have appeared to change the structure of landscape ecology, promoting homogenization of habitats, resulting in dramatic changes in biotic communities (McKinney, 2006). Usually urbanization has an effect on decreasing biodiversity, though there are some urban wildlife species living in such environments. Wildlife living in urban areas faces more stress than their counter-parts living outside of cities (Gibbs et al., 2019). However, there are also a range of benefits to living in urban

habitats e.g., greater food availability (Jessop et al., 2012), less predation pressure (Rebolo-Ifran et al., 2017), and a refugium from many natural infectious diseases (Saenz et al., 2015). Urban habitats also create corridors for individuals that need to move through cities (FitzGibbon et al., 2007) and play an important ecological role in protecting local biodiversity by providing shelter (Crooks et al., 2004; Aronson et al., 2017).

Urban wildlife also provide important ecosystem services that benefit humans through the regulation of insect and rodent populations (Sekercioglu et al., 2004), seed dispersal and pollination (Sekercioglu et al., 2004; Mendes et al., 2008), removal of carcasses and nutrient cycling (Pain et al., 2003). They also promote economic benefits such as bird watching tourism (Sekercioglu, 2002) and an increase in property value (Bolitzer & Netusil, 2000). Most importantly, urban wildlife is sharing the same habitats with urban citizens in the surrounding environments (Magle et al., 2012). Therefore, urban wildlife is now considered as a part of modern city life. For a functional urban ecosystem, it is important to maintain the balance between a healthy ecosystem and changes due to urbanization. In this light, because the knowledge gap about the importance of these groups of animals living among people may lead to conflicts in wildlife management (Kato et al., 2019), the study of urban animals, including their ecology, diversity, distribution and status is extremely important. Urban wildlife management is a new concept, compared to wildlife game management and damage control strategies (McCance et al., 2017). Therefore, baseline data on urban wildlife is essential for properly informed urban management planning in the future. Understanding the importance of animals in modern life, research on urban wildlife is increasing worldwide (Magle et al., 2012).

Studies on urban wildlife in developing Asian countries are few compared to the developed countries in North America and Europe (Magle et al., 2012). For instance, Dhaka, one of the oldest and biggest cities in Asia, does not have a comprehensive urban wildlife and conservation management plan for sustainable urban development. Dhaka is one of the fastest growing megacities in terms of urban transformation and subsequent environmental change (Islam & Ahmed, 2011; Akash et al., 2018). There are several ongoing megaprojects (for example, metrorails, flyovers/multilayer roads) and recent expansion of the city at Uttara altered the natural habitats and changed the landscape structure that may eventually favorably affect urban wildlife. Furthermore, some recent findings from Dhaka city, such as the discovery of a new frog species, *Fejervarya dhaka* (Howlader et al., 2016), new bird colonies (Sahadat Hossain, pers.com. official of Bangladesh Bird Club) and some new locality records of reptile species (Sarker, 2013; Hasan et al., 2014), revealed this city to be an important new site for wildlife studies. On the other hand, Islam & Ahmed (2011) recently showed that during the period from 1991–2008, 14.59% of agricultural land, 16.92% of grassy and bushy areas and some large and small trees in and around human settlements, 10.27% of waterbodies, and 1.28% wet/or lowlands were lost while 14.84% land covered with new residential and commercial buildings and infrastructures. All taken together, these facts suggest that Dhaka is a good model for studying urban wildlife. These studies in future may give the direction to better understanding the effects of urbanization on them.

Despite the importance and potential, research on wildlife diversity in Dhaka megacity is still underrepresented with only a handful numbers of articles published to date. Among these for instance are about the avifauna of Uttara (Sarker et al., 2009), avifauna of Dhaka University campus (Akash et al., 2013; Chowdhury et al., 2014; Banu et al., 2016), birds in the National Botanical Garden (NBG) (Islam et al., 2014), Keraniganj (Jaman et al., 2014), Ramna park (Rajia et al., 2015), some herpetological studies (Sarker, 2013; Hasan et al., 2014) and a dolphin survey in an adjacent river (Hossain & Baki, 2015). The published literature indicates that the previous studies in Dhaka city were conducted on some scattered localities, mainly focusing on single taxa. In addition, there has been no single study recording everything from Amphibia to Mammalia in the whole of Dhaka city. Moreover, we identified some untouched areas not studied previously that indicate important gaps in our knowledge of the city's wildlife. Given that there appears to be a geographic bias and a limited focus on wildlife species studied within the megacity, the overall diversity, distribution, habitat use and conservation status of wildlife species in Dhaka city have not yet been fully documented. This study aimed to provide baseline data on overall urban wildlife diversity, patterns of species distribution, habitat use and current conservation status in the rapidly changing urbanized landscape of Dhaka

city. This study also aimed to fill in the research gaps on wildlife diversity by considering all locations under this study.

MATERIAL AND METHODS

Study sites and habitats surveyed

The study was conducted from September 2015 to November 2018 at 11 sites in Dhaka city (23.7°N, 90.4°E), including parks, lakes, ponds, roadsides, homestead gardens, agricultural lands and public gardens (Table 1; Fig. 1). These study sites were selected based on the preliminary survey of the potential wildlife habitats and focused discussion with local stakeholders.

Data collection

During the survey, we collected information on the number of species, abundance, habitats and substrate utilization, as well as potential threats to wildlife. We spent 33 (11 locations×3 months)

Site name (area km^2)	**Habitat surveyed in the study areas**
Agargaon (1.2)	Sher-e-Bangla Agricultural University (SAU) Campus: Gardens and agriculture experiment fields, ponds, temporary waterbodies, roadside vegetation, building walls
Demra (6.88)	Mogdapara and Matuail: Human habitations, roadside trees, small waterbodies
	Jatrabari: homestead areas, gardens and planted trees
Gulistan (0.26)	Dhaka Mahanagar Nattomoncho Park trees, Osmani Park, Nagar Bhaban gardens
Gulshan (2.84)	Gulshan park garden and lake waterbodies
Mirpur (1.67)	NBG: trees, grasslands and lake water
	Dhaka Zoo: Planted trees, grasslands and lake water
Mohakhali (1.43)	Shaheen College yards, Dhaka Cantonment gardens, Shahid Sarani gardens and trees
Mohammadpur (0.90)	Chandrima Udyan, Mohammadpur and Bosila: Residential area, planted trees, growing urban areas
	Rayer Bazar Graveyard: Around lakesides, roadside plants and building
Old Dhaka (0.94)	Buriganga river sides, trees, waterbodies
	Balda Garden: Planted garden and trees
Ramna (0.80)	Ramna Park: Lakes, waterbodies, plants, roadside plants and grasslands
	Baily Road homestead areas and roadside plants
Shahbagh (1.87)	University of Dhaka Campus: Garden plants, temporary waterbodies, pond, buildings
	Suhrawardy Udyan: Plants, ponds, grasslands and temporary waterbodies
	Buildings and Malchattar
	North and South Fuller Road homestead plants
	Bangladesh University of Engineering and Technology (BUET) Campus: gardens, community forest and university campus.
	North & south Fuller Road homestead areas
	University of Dhaka Giasuddin Residential Area, trees
Uttara (14.21)	Uttara (Badda-Aftabnagar and Diabari): building walls, drains, roadside plantations, waterbodies, grasslands

Table 1. The habitats surveyed at different study sites during the study period.

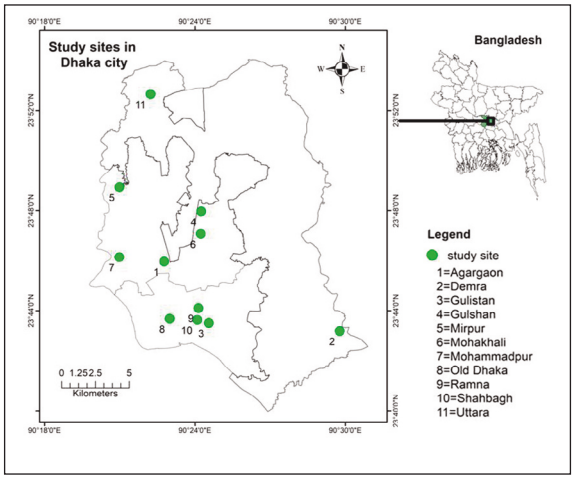

Figure 1. Study sites in Dhaka city.

months for data collection during the study period and visited each site at least three times, once each in summer, rainy season and winter. We surveyed 24 (3seasons×8 days) days per site totaling 264 (11sites×24 days) days with equal effort for each group of wildlife. We surveyed approximately 160,000 square meters in each site; visited each transect line and remarked areas three times across seasons and used all methods (i.e. transect line survey for the bird and mammal, visual encounter survey - 'VES' of herpetofauna). We conducted diurnal and nocturnal surveys employing several methods to collect data on four different groups of wildlife. Species were primarily identified by direct observation and scrutinizing of photographs. We photographed the observed species by using DSLR cameras and Canon Power shot A2500. For species identification and nomenclature, we followed Halder (2010), Khan (2015) and Khan (2018) for birds; Khan (2004), Hasan et al. (2014), Khan (2018), Uetz et al. (2019) and Frost (2020) for herpetofauna and Khan (2015, 2018) for mammals.

Amphibians and Reptiles. We conducted VES randomly, but equally (in terms of area) in each site for herpetofauna survey in the day (from 10:00 am to 2:00 pm) and night (from 6:00 pm to 12:00 am). Nocturnal VES was most successful for amphibians and some nocturnal reptiles in the rainy season (Wheater et al., 2011). We walked along the trails across the habitats and actively looked for exposed or active animals. We used handheld flashlights and head torches during night observations (Gent & Gibson, 2003). We recorded vocalizations and analyzed them for the identification of cryptic frog species (Khan, 2004; Hasan et al., 2014; Khan, 2018; Uetz et al., 2019 and Frost, 2020). Lizards were counted while walking on the study site. In many cases, we searched for camouflaged herpetofauna in their preferred microhabitats (e.g., grassland, bushy areas, trees, buildings) and sometimes located them by their calls.

Birds. We counted avifauna populations using binoculars (Prism a 20×50) and recorded species using the line transect method from 5:30 am to 11:30 pm (van Heezik & Seddon, 2012). Widths of each transect line varied from 10 m to 30 m in width and from 200 m to 1000 m in length, depending on the location of habitats we surveyed. Although transect number and total area varied in different study sites, we ensured covering similar volume of area in all selected sites. For example, to cover small fragmented areas like Gulisthan, we surveyed 32 transects totaling 160,000 square meters of varied sizes; 2 transects (250×10×2 square meter), 20 transects (400×10×20 square meter) and 10 transects (500×15×10 square meter). Whereas for Uttara, we surveyed 17 transects covering a similar areas we did for Gulisthan, but sizes of transects varied; 5 transects (800×20×5 square meter), 2 transects (1000×30×2 square meter) and 10 transects (200×10×10 square meter). We also surveyed at night for nocturnal birds from 6:00 pm to 12:00 pm and traced individuals by their calls. Sometimes we counted birds their calls and songs and in a few cases, we recorded calls and later identified them. We contacted dedicated birders of Dhaka city to know the breeding and roosting sites for migratory and colonial birds and later surveyed those areas.

Mammals. We collected data on mammals in the same transect lines used for birds at the same time. We opportunistically searched most of the natural habitats in transects to record mammals. We did nocturnal surveys for nocturnal carnivores and rodents from 6:00 pm to 12:00 pm (following Wheater et al., 2011); traced them by footprints, scat and fur traces. Aquatic and flying mammals were photographed and later identified. In some areas, we interviewed local people to get information on available mammalian species. We showed them photographs available in the field pictorial guides and confirmed species identification based on their descriptions.

Habitat survey

We recorded urban wildlife from various microhabitats. These microhabitats are small recognizable areas within a habitat and were divided into Grassland (GL) and Tree (T), Roadside area (RA), Permanent waterbody (PW), Temporary waterbody (TW), Urban settlement (US), and Flying condition. Grassland includes grassy and bushy areas; Tree includes large and small trees in patchy areas, planted trees, gardens; Roadside area includes the land that is along a road; Permanent waterbody includes ponds, lakes, and river; Temporary waterbody includes pools, canals, small water bodies, and drains; and urban settlement includes buildings, construction sites, residential and commercial areas. Some wildlife, especially birds and flying mammals, were recorded in flight and were not observed resting in other habitat types. We recorded these habitat as "Flying". We classified substrates vertically as ground layers (animal counting from the ground), lower canopy (≤4 m height), middle canopy (>4 m – <6 m height) and upper canopy (>6 m height).

Data analysis

Data collected for amphibians, reptiles, birds and mammals were analyzed in spreadsheets for diversity index, relative abundance, habitat, and substrate utilization in different sites. We compared the site-wise diversity index and evenness following the method of Shannon-Wiener index (Shannon & Weaver, 1949). We also investigated the similarity of species composition in the sites studied. We calculated similarity indices for the eleven study sites using EstimateS software (Chao et al., 2005). We did not compare seasonal diversity as amphibians and reptiles were mostly observed in the rainy season, which would bias their seasonal diversity. We calculated the frequency of occurrence (n), which means how many times a particular species in each site, was observed. Relative abundance (RA) was calculated following Hasan et al., (2014) as very common (75–100% of occurrence), common (51–74% of occurrence), uncommon (26–50% of occurrence) and rare (<26% of occurrence). [RA equation: number of observations of the species at different sites (n)/total number of observations (here, 11)*100. If a species is seen in all study sites (11), then RA=11/11*100=100% (very common); if a species is seen in 5 out of 11 sites, then RA=5/11*100=45% (uncommon)]. Relative abundance was calculated to estimate the status of the observed species in Dhaka city. We also appended data of regional conservation status from the IUCN Red List Bangladesh (IUCN Bangladesh, 2015).

RESULTS

Species diversity, composition and Shannon index

A total of 209 species were recorded across the study sites (Table 3). Among them, 12 (5.74%) species were amphibians, 19 (9.09%) reptiles, 162 (77.5%) birds and 16 (7.66%) were mammals. These amphibians, reptiles, birds and mammals belonged to 5, 11, 52 and 11 families, respectively (Table 3). Among the total species observed, 65.6%, (137) were in Uttara followed by 44.5% (93) in Mirpur, 26.3% (55) in Shahbagh, 23.9% (50) in Old Dhaka and 20.6% (43) in Ramna (Fig. 2). According to taxa, the numbers of recorded species from different study sites are shown in Fig. 2.

A total of 13,805 individuals were counted from the study sites (Table 3). Among them, birds were the highest in number (88%, 12,183) followed by mammals (6.3%, 872), amphibians (4.4%, 605), and reptilians (1.05%, 145, Table 3). Regarding the site-wise total count of individuals, the highest number of individuals was counted at Shahbag (22%, 3,039) followed by Ramna (18.7%, 2,576), Uttara (15.3%, 2,108) and Mirpur (13.6%, 1,872) (Table 3).

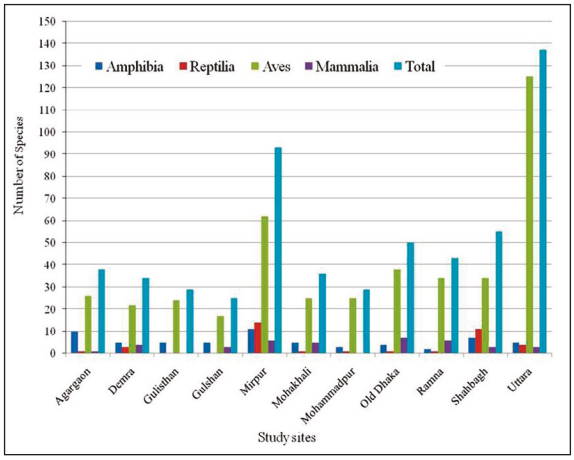

Figure 2. Species richness of wildlife recorded at different study sites of urban Dhaka megacity.

Parameter	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	Site 9	Site 10	Site 11
Shannon-Wiener Index (H′)	3.350	2.871	2.003	2.962	3.647	2.555	2.734	3.077	2.720	2.829	4.198
Evenness (E)	0.921	0.814	0.595	0.920	0.805	0.713	0.812	0.786	0.723	0.706	0.853

Table 2. Shannon-Wiener indices listed by the study site. (Site 1- Agargaon; Site 2- Demra; Site 3- Gulistan; Site 4- Gulshan; Site 5- Mirpur; Site 6- Mohakhali; Site 7-Mohammadpur; Site 8- Old Dhaka; Site 9-Ramna; Site 10-Shahbag, and Site 11-Uttara).

The highest value of Shannon-Wiener index was calculated (H′= 4.198) for site no.11 (Uttara), followed by 3.64 for site 5 (Mirpur), 3.35 for site 1 (Agargaon), 3.07 for site 8 (Old Dhaka) (Table 2). Species were more evenly distributed in the Agargaon site (E = 0.921), probably due to the abundance of homestead trees that are lacking in Gulistan (E = 0.595) (Table 2).

Relative abundance

Among the total species of wildlife, 20 (9.6%) were very common, 16 (7.7%) common, 20 (9.6%) uncommon and 153 (73.2%) species were rare (Table 3). Among amphibians, 2 (16.7%) species were very common, 4 (33.3%) common, 3 (25%) uncommon, and 3 (25%) species were rare (Table 3). Among reptiles, 18 (94.7%) species were rare and the remaining one (5.3%) species was common. Among 162 species of birds, 120 (74.1%) were rare, 16 (9.9%) were uncommon, 15 (9.3%) were very common and 11 (6.8%) were common. Of the recorded mammals, 12 (75%) species were rare, 3 (18.8%) very common and 1 (6.3%) species was uncommon in Dhaka city (Table 3).

Species similarity index

Some species shared different habitats with other species. The similarity index indicates the sharing of habitats by the number of species recorded. The calculated index values range from 0.13 to 0.52 (average=0.33) for pair-wise study sites, which means that on average 33% of the recorded species were common in all eleven sites (Table 3).

Habitat and substrate utilization

Species were the most abundant in trees than in other microhabitats; those being mostly birds. When comparing overall species in microhabitat types, 117 species were found in trees followed by 78 in grassland, 50 in urban settlements, 36 on permanent waterbodies, 30 on temporary waterbodies (Fig. 3).

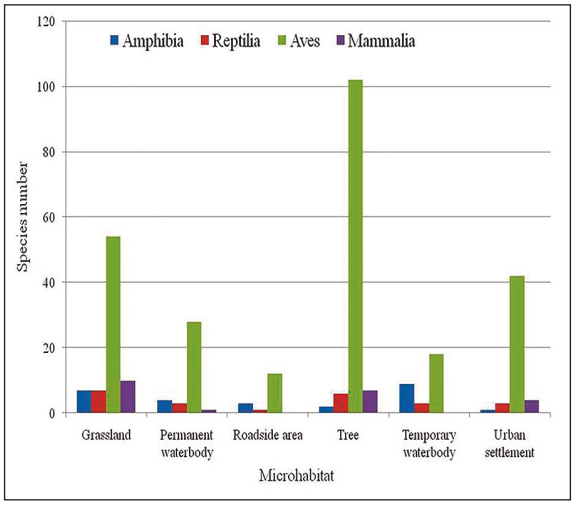

Figure 3. Microhabitat usage of wildlife in urban Dhaka city.

Amphibians were mostly recorded from permanent and temporary waterbodies and near its grasslands. Seven species of reptiles used grassland, which was their most frequently used microhabitat. Among birds, the highest numbers of species (102) were recorded in trees and the lowest (3) were observed while flying. For mammals, the highest (10) species were found in grasslands.

All wildlife species were found using different vertical layers of habitat and they frequently move in different canopy levels for foraging and displaying other activities. Among them, 118 species used ground layers, which was the highest followed by 84 species in middle canopy, 71 in upper canopy, 62 in lower canopy and 56 in man height layer (Fig. 4). We found 17 species that utilized all substrate types (Fig. 4). The unique species number observed for different substrates is 72 for ground layer, 8 for lower canopy, 21 for middle canopy, 19 for upper canopy, and 7 for man height layer (Fig. 4).

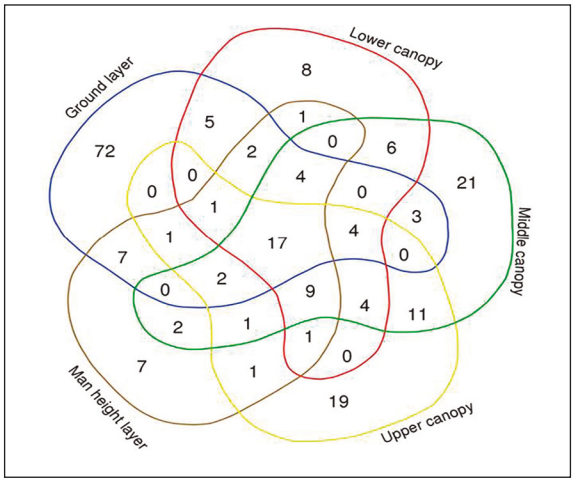

Figure 4. Substrate utilization of wild animals in Dhaka city (number denoted the species those utilized and shared single and or multiple substrates).

Threatened status

According to IUCN Bangladesh (2015), among the 209 species of wildlife listed here, eight were Near Threatened (three reptiles, two birds and three mammals), two species Vulnerable (mammals), two species Data Deficient (bird), and 197 species were Least Concern (Table 3).

DISCUSSION

Species composition, abundance and distribution

Urban habitats sometimes provide benefits for wildlife such as stable food availability, absence of natural predators and even green corridors for animals to move or migrate through, playing a vital ecological role in protecting local biodiversity. Our study has provided substantial baseline data on diverse taxa of wildlife with a significant number of different species, distribution and habitat utilization in the urbanized Dhaka megacity. The most diverse amphibian species were found in the family Dicroglossidae, having 8 (67%) species of frogs. The most frequently observed species was the Asian Common Toad (21.2%, 128 indiv.) and the least common was the Green Frog (0.33%, 2 indiv.), sighted only in NBG. Some amphibians were recorded only from one site. Of the recorded amphibians, the Marbled Toad, Jerdon's Bull Frog, and Balloon Frog were not observed in this study but were recorded earlier by Reza & Perry (2015). They reported herpetofaunal species occurrence using both direct observation and literature searching while we only used VES for this study. For this reason, we found fewer species of herpetofauna

Order and Family name	Common Name	Scientific Name	n	No. of Individual	RA	IUCN Status	Microhabitat
Amphibia							
Anura Bufonidae	Asian Common Toad	*Duttaphrynus melanostictus*	11	128	VC	LC	GL, PW, RS, TW, US
	Indian Bull Frog	*Hoplobatrachus tigerinus*	10	60	C	LC	GL, TW
	Green Frog	*Euphlyctis hexadactylus*	1	2	R	LC	PW
	Skipper Frog	*E. cyanophlyctis*	10	68	C	LC	PW, TW
	Kalasgram Skipper Frog	*E. kalasgramensis*	1	7	R	LC	PW
	Pierre's Cricket Frog	*Fejervarya pierrei*	2	29	UC	LC	GL, TW
	Asmat's Cricket Frog	*F. asmati*	6	90	VC	LC	GL, TW
	Bombay Wart Frog	*F. syhadrensis*	6	71	C	LC	GL, RA, TW
	Terai Cricket Frog	*F. teraiensis*	7	74	C	LC	GL, TW
Rhacophoridae	Common Tree Frog	*Polypedates leucomystax*	4	27	UC	LC	T

Order and Family name	Common Name	Scientific Name	n	No. of Individual	RA	IUCN Status	Microhabitat
Microhylidae	Narrow-mouthed Frog	*Microhyla* sp.	3	44	UC	LC	GL, RS, TW
Ranidae	Yellow-striped Frog	*Hylarana tytleri*	1	5	R	LC	PW, T
Reptilia							
Squamata Varanidae	Bengal Monitor	*Varanus bengalensis*	2	12	R	NT	GL, RS
Elapidae	Monocled Cobra	*Naja kaouthia*	3	3	R	NT	GL
	Binocled Cobra	*N. naja*	3	6	R	NT	GL
Natricidae	Checkered Keelback	*Xenochrophis piscator*	3	4	R	LC	PW, TW
	Striped Keelback	*Amphiesma stolatum*	1	1	R	LC	PW
Typhlopidae	Brahminy Blind Snake	*Ramphotyphlops braminus*	2	4	R	LC	GL
Gekkonidae	Common House Gecko	*Hemidactylus frenatus*	3	25	R	LC	T, US
	Yellow-green House Lizard	*H. flaviviridis*	4	54	C	LC	T, US
	Brook's House Gecko	*H. brookii*	2	12	R	LC	US
	Tokay Gecko	*Gekko gecko*	1	1	R	LC	T
Scincidae	Common Skink	*Eutropis carinata*	1	1	R	LC	GL
	White-spotted Supple Skink	*Lygosoma albopunctata*	1	1	R	LC	GL
Colubridae	Common Wolf Snake	*Lycodon aulicus*	1	1	R	LC	T
	Common Bronzeback Tree Snake	*Dendrelaphis tristis*	1	1	R	LC	T
	Indian Rat Snake	*Ptyas mucosa*	3	9	R	LC	GL
Agamidae	Common Garden Lizard	*Calotes versicolor*	1	4	R	LC	T
Homalopsidae	Smooth water Snake	*Enhydris enhydris*	2	2	R	LC	PW
Testudines Geomydidae	Roofed Turtle	*Pangshura tecta*	1	4	R	LC	TW
Aves							
Accipitriformes Accipitridae	Long-legged Buzzard	*Buteo rufinus*	1	5	R	LC	T
	Shikra	*Accipiter badius*	2	3	R	LC	T
	Black Kite	*Milvus migrans*	10	780	VC	LC	Flying, GL, T
	Black-winged Kite	*Elanus caeruleus*	3	5	UC	LC	T, US
	Brahminy Kite	*Haliastur indus*	4	17	UC	LC	T, US
	Crested Serpent Eagle	*Spilornis cheela*	1	1	R	LC	US
Pandionidae	Osprey	*Pandion haliaetus*	1	3	R	LC	US
Anseriformes Anatidae	Lesser Whistling Duck	*Dendrocygna javanica*	1	2	R	LC	PW
Bucerotiformes Upupidae	Common Hoopoe	*Upupa epops*	1	2	R	LC	GL

Order and Family name	Common Name	Scientific Name	n	No. of Individual	RA	IUCN Status	Microhabitat
Coraciformes Coraciidae	Indochinese Roller	*Coracias affinis*	1	1	R	LC	US
	Indian Roller	*C. benghalensis*	1	9	R	LC	T, US
Meropidae	Green Bee-eater	*Merops orientalis*	1	2	R	LC	T
Alcedinidae	Common Kingfisher	*Alcedo atthis*	8	39	C	LC	GL, PW, T
	Pied Kingfisher	*Ceryle rudis*	1	11	R	LC	T, US
	Stork-billed Kingfisher	*Pelargopsis capensis*	2	16	R	LC	PW, T
	White-breasted Kingfisher	*Halcyon smyrnensis*	10	102	VC	LC	PW, T, US
Caprimulgiformes Apodidae	Asian Palm Swift	*Cypsiurus balasiensis*	6	329	C	LC	Flying, GL, T
	House Swift	*Apus nipalensis*	8	586	C	LC	Flying, T, US
Caprimulgidae	Large-tailed Nightjar	*Caprimulgus macrurus*	1	3	R	LC	T
Charadriformes Charadridae	Kentish Plover	*Charadrius alexandrinus*	1	2	R	LC	TW
	Little Ringed Plover	*C. dubius*	1	156	R	LC	PW, TW
	Red-wattled Lapwing	*Vanellus indicus*	1	5	R	LC	GL, TW
	River Lapwing	*V. duvaucelii*	1	5	R	NT	PW
Jacanidae	Bronze-winged Jacana	*Metopidius indicus*	2	3	R	LC	PW
Rostratulidae	Greater Painted Snipe	*Rostratula benghalensis*	1	2	R	LC	GL
Scolopacidae	Wood Sandpiper	*Tringa glareola*	1	2	R	LC	TW
	Common Sandpiper	*Actitis hypoleucos*	1	103	R	LC	PW, TW
	Common Snipe	*Gallinago gallinago*	1	2	R	LC	PW
	Pin-tailed Snipe	*G. stenura*	1	2	R	LC	PW
	Little Stint	*Calidris minuta*	1	4	R	LC	TW
	Temminck's Stint	*C. temminckii*	1	8	R	LC	TW
Psittaciformes Psittacidae	Alexandrine parakeet	*Psittacula eupatria*	4	13	UC	LC	T
	Plum-headed Parakeet	*P. cyanocephala*	1	3	R	LC	US
	Red-breasted Parakeet	*P. alexandri*	1	2	R	LC	T
	Rose-ringed Parakeet	*P. krameri*	10	224	VC	LC	T, US
Falconiformes Falconidae	Amur Falcon	*Falco amurensis*	1	1	R	LC	US
	Red-headed Falcon	*F. chicquera*	2	3	R	LC	T
	Common Kestrel	*F. tinnunculus*	1	8	R	LC	T, US
Passeriformes Dicruridae	Ashy Drongo	*Dicrurus leucophaeus*	1	4	R	LC	US
	Black Drongo	*D. macrocercus*	11	208	VC	LC	GL, RS, T,US
	Bronzed Drongo	*D. aeneus*	1	2	R	LC	US

Order and Family name	Common Name	Scientific Name	n	No. of Individual	RA	IUCN Status	Microhabitat
	Lesser Racket-tailed Drongo	*D. remifer*	1	1	R	LC	US
Artamidae	Ashy Woodswallow	*Artamus fuscus*	1	3	R	LC	US
Aegithinidae	Common Iora	*Aegithina tiphia*	2	11	R	LC	T
Alaudidae	Greater Short-toed Lark	*Calandrella brachydactyla*	1	15	R	DD	GL
	Bengal Bush Lark	*Mirafra assamica*	1	9	R	LC	GL
Campephagidae	Black-headed Cuckooshrike	*Coracina melanoptera*	1	2	R	LC	T
	Black-winged Cuckooshrike	*C. melaschistos*	1	1	R	LC	T
	Small Minivet	*Pericrocotus cinnamomeus*	1	1	R	LC	US
	Large Woodshrike	*Tephrodornis gularis*	1	5	R	LC	GL
Cisticolidae	Plain Prinia	*Prinia inornata*	4	45	UC	LC	GL, T
	Grey-breasted Prinia	*P. hodgsonii*	1	4	R	LC	PW
	Zitting Cisticola	*Cisticola juncidis*	5	140	UC	LC	GL, RS, T, US
Corvidae	Rufous Treepie	*Dendrocitta vagabunda*	5	38	UC	LC	T
	Large-billed Crow	*Corvus levaillantii*	8	275	C	LC	GL, RS, T, US
	House Crow	*C. splendens*	11	2050	VC	LC	GL, RS, T, US
Dicaeidae	Pale-billed Flowerpecker	*Dicaeum erythrorhynchos*	1	3	R	LC	T
Estrildidae	Chestnut Munia	*Lonchura atricapilla*	3	60	UC	LC	GL, T
	Scaly-breasted Munia	*L. punctulata*	1	12	R	LC	GL, T
	Tricolored Munia	*L. malacca*	1	5	R	LC	GL
	White-rumped Munia	*L. striata*	1	10	R	LC	T
	White-throated Munia	*L. malabarica*	2	23	R	LC	GL
	Red Avadavat	*Amandava amandava*	1	15	R	LC	GL
Hirundinidae	Barn Swallow	*Hirundo rustica*	2	21	R	LC	US
	Red-rumped Swallow	*H. daurica*	1	2	R	LC	T
Lanidae	Brown Shrike	*Lanius cristatus*	2	3	R	LC	T
	Long-tailed Shrike	*L. schach*	4	37	UC	LC	GL, T, US
	Grey-backed Shrike	*L. tephronotus*	1	1	R	LC	T
Monarchidae	Black-naped Monarch	*Hypothymis azurea*	1	2	R	LC	T
	Asian Paradise Flycatcher	*Terpsiphone paradisi*	1	1	R	LC	T
Motacillidae	Olive-backed Pipit	*Anthus hodgsoni*	1	2	R	LC	GL
	Paddyfield Pipit	*A. rufulus*	1	7	R	LC	GL, RS, US

Order and Family name	Common Name	Scientific Name	n	No. of Individual	RA	IUCN Status	Microhabitat
	Richard's Pipit	*A. richardi*	1	3	R	LC	GL
	Citrine Wagtail	*Motacilla citreola*	1	18	R	LC	GL, PW
	White-browed Wagtail	*M. madaraspatensis*	1	1	R	LC	PW
	Yellow Wagtail	*M. flava*	1	15	R	LC	GL, PW, TW
Muscicapidae	Common Stonechat	*Saxicola torquatus*	1	19	R	LC	GL
	Pied Bushchat	*S. caprata*	1	4	R	LC	GL
	White-tailed Stonechat	*S. leucurus*	1	2	R	LC	GL
	Oriental Magpie Robin	*Copsychus saularis*	10	449	VC	LC	GL, RS, T, US
	Taiga Flycatcher	*Ficedula albicilla*	1	1	R	LC	T
	Grey-headed Canary Flycatcher	*Culicicapa ceylonensis*	1	17	R	LC	T
	Verditer Flycatcher	*Eumyias thalassina*	1	1	R	LC	T
	Black Redstart	*Phoenicurus ochruros*	1	1	R	LC	GL
	Bluethroat	*Luscinia svecica*	1	2	R	LC	T
	Siberian Blue Robin	*L. cyane*	1	1	R	LC	T
	Siberian Rubythroat	*L. calliope*	1	1	R	LC	GL
Nectariniidae	Purple Sunbird	*Nectarinia asiatica*	5	31	UC	LC	T
	Purple-rumped Sunbird	*N. zeylonica*	2	3	R	LC	T
Oriolidae	Black-hooded Oriole	*Oriolus xanthornus*	7	77	C	LC	T, US
	Black-naped Oriole	*O. chinensis*	3	8	UC	LC	T
	Eurasian Golden Oriole	*O. oriolus*	1	1	R	LC	T
Paridae	Great Tit	*Parus major*	2	15	R	LC	T
Passeridae	House Sparrow	*Passer domesticus*	11	1378	VC	LC	GL, RS, T, US
Ploceidae	Baya Weaver	*Ploceus philippinus*	3	19	UC	LC	T
Rhipiduridae	White-throated Fantail	*Rhipidura albicollis*	1	1	R	LC	T
Pycnonotidae	Red-whiskered Bulbul	*Pycnonotus jocosus*	1	1	R	LC	T
	Red-vented Bulbul	*P. cafer*	11	442	VC	LC	GL, T, US
Sturnidae	Bank Myna	*Acridotheres ginginianus*	1	19	R	LC	GL, PW, TW
	Common Myna	*A. tristis*	10	1099	VC	LC	GL, RS, T,US
	Jungle Myna	*A. fuscus*	8	294	C	LC	GL, T, US
	Asian Pied Starling	*Sturnus contra*	11	1079	VC	LC	GL, RS, T,US
	Chestnut-tailed Starling	*S. malabaricus*	9	262	VC	LC	GL, T, US

Order and Family name	Common Name	Scientific Name	n	No. of Individual	RA	IUCN Status	Microhabitat
Sylviidae	Dusky Warbler	*Phylloscopus fuscatus*	1	7	R	LC	PW, T
	Clamorous Reedwarbler	*Acrocephalus stentoreus*	1	11	R	LC	T
	Common Tailorbird	*Orthotomus sutorius*	8	123	C	LC	T
	Striated Grassbird	*Megalurus palustris*	1	7	R	LC	GL, T
	Blyth's Reed Warbler	*Acrocephalus dumetorum*	2	7	R	LC	T
Timaliidae	Striated Babbler	*Turdoides earlei*	1	2	R	LC	GL
	Jungle Babbler	*T. striata*	2	46	R	LC	GL, T
Turdidae	Eurasian Scaly Thrush	*Zoothera dauma*	2	2	R	LC	T
	Orange-headed Thrush	*Z. citrina*	1	5	R	LC	T
Zestropodidae	Oriental White-eye	*Zosterops palpebrosus*	1	12	R	LC	T
Gruiformes Rallidae	Common Moorhen	*Gallinula chloropus*	1	3	R	LC	PW, TW
	White-breasted Waterhen	*Amaurornis phoenicurus*	2	10	R	LC	PW, T, TW
Cuculiformes Cuculidae	Asian Koel	*Eudynamys scolopaceus*	7	60	C	LC	T, US
	Indian Cuckoo	*Cuculus micropterus*	1	4	R	LC	T
	Common Cuckoo	*C. canorus*	1	4	R	DD	T
	Common Hawk Cuckoo	*Hierococcyx varius*	1	3	R	LC	T
	Plaintive Cuckoo	*Cacomantis merulinus*	4	6	UC	LC	T
	Jacobin Cuckoo	*Clamator jacobinus*	2	4	R	LC	T
	Green-billed Malkoha	*Phaenicophaeus tristis*	1	2	R	LC	T
	Greater Coucal	*Centropus sinensis*	2	6	R	LC	T
	Lesser Coucal	*C. bengalensis*	1	2	R	LC	GL
Pelecaniformes Ardeidae	Black-crowned Night Heron	*Nycticorax nycticorax*	2	71	R	LC	T
	Black Bittern	*Ixobrychus flavicollis*	1	1	R	NT	TW
	Cinnamon Bittern	*I. cinnamomeus*	1	6	R	LC	GL
	Yellow Bittern	*I. sinensis*	1	9	R	LC	GL, PW, TW, US
	Cattle Egret	*Bubulcus ibis*	1	1	R	LC	GL
	Intermediate Egret	*Ardea intermedia*	1	1	R	LC	PW
	Little Egret	*Egretta garzetta*	3	9	UC	LC	GL, PW
	Great White Egret	*Ardea alba*	1	8	R	LC	PW, TW
	Purple Heron	*A. purpurea*	1	1	R	LC	TW
	Grey Heron	*A. cinerea*	1	90	R	LC	PW, TW

Order and Family name	Common Name	Scientific Name	n	No. of Individual	RA	IUCN Status	Microhabitat
	Little Heron	*Butorides striata*	3	5	UC	LC	GL, PW, T
	Indian Pond Heron	*Ardeola grayii*	9	91	VC	LC	GL, PW, T, TW
Piciformes Picidae	Eurasian Wryneck	*Jynx torquilla*	1	6	R	LC	GL, T
	Black-rumped Flameback	*Dinopium benghalense*	9	80	VC	LC	GL, RS, T
	Greater Flameback	*Chrysocolaptes guttacristatus*	1	11	R	LC	T
	Fulvous-breasted Woodpecker	*Dendrocopos macei*	7	45	C	LC	T, US
	Rufous Woodpecker	*Micropternus brachyurus*	2	12	R	LC	T
Megalaimidae	Blue-throated Barbet	*Psilopogon asiaticus*	1	2	R	LC	T
	Lineated Barbet	*P. lineatus*	2	19	R	LC	T
	Coppersmith Barbet	*P. haemacephalus*	7	87	C	LC	T
Podicipediformes Podicipedidae	Little Grebe	*Tachybaptus ruficollis*	1	4	R	LC	PW
Strigiformes Strigidae	Brown Boobook	*Ninox scutulata*	1	1	R	LC	T
	Brown Fish Owl	*Ketupa zeylonensis*	1	1	R	LC	T
	Collared Scops Owl	*Otus lettia*	1	1	R	LC	T
	Short Eared Owl	*Asio flammeus*	1	1	R	LC	T
	Spotted Owlet	*Athene brama*	3	11	UC	LC	T
Tytonidae	Common Barn Owl	*Tyto alba*	1	1	R	LC	US
Suliformes Phalacrocoracidae	Great Cormorant	*Phalacrocorax carbo*	1	8	R	LC	PW
	Little Cormorant	*Microcarbo niger*	10	154	VC	LC	GL, PW, T, TW, US
Ciconiiformes Ciconiidae	Asian Openbill	*Anastomus oscitans*	1	4	R	LC	T
Columbiformes Columbidae	Orange-breasted Green Pigeo	*Treron bicinctus*	1	1	R	LC	T
	Yellow footed Green Pigeon	*T. phoenicopterus*	1	3	R	LC	T
	Eurasian Collared Dove	*Streptopelia decaocto*	3	11	UC	LC	T, US
	Red Turtle Dove	*S. tranquebarica*	1	7	R	LC	T, US
	Green Imperial Pigeon	*Ducula aenea*	1	1	R	LC	T
	Grey-capped Emerald Dove	*Chalcophaps indica*	1	1	R	LC	GL
	Rock Pigeon	*Columba livia*	8	124	C	LC	GL,RS, T, US
	Spotted Dove	*Spilopelia chinensis*	10	222	VC	LC	GL, RS, T, US
Mammalia							
Carnivora Canidae	Goden Jackal	*Canis aureus*	1	1	R	LC	GL
Herpestidae	Common Mongoose	*Herpestes edwardsii*	5	15	R	LC	GL, T, US

Order and Family name	Common Name	Scientific Name	n	No. of Individual	RA	IUCN Status	Microhabitat
Felidae	Jungle Cat	*Felis chaus*	1	1	R	NT	GL
Viverridae	Common Palm Civet	*Paradoxurus hermaphroditus*	1	1	R	LC	GL
	Large Indian Civet	*Viverra zibetha*	2	2	R	NT	GL
	Small Indian Civet	*Viverricula indica*	2	2	R	NT	GL
Cetartiodactyla Platanistidae	Ganges River Dolphin	*Platanista gangetica*	1	3	R	VU	PW
Chiroptera Pteropodidae	Greater Short-nosed fruit Bat	*Cynopterus sphinx*	3	15	R	LC	T
	Indian Flying Fox	*Pteropus giganteus*	6	417	VC	LC	GL, US
Vespertilionidae	Indian Pipistrelle	*Pipistrellus coromandra*	1	1	R	LC	T
Rodentia Sciuridae	Irrawaddy Squirrel	*Callosciurus pygerythrus*	3	40	UC	LC	T
	Five-striped Palm Squirrel	*Funambulus pennantii*	4	108	VC	LC	GL, T, US
Muridae	Greater Bandicoot Rat	*Bandicota bengalensis*	1	1	R	LC	GL
	Lesser Bandicoot Rat	*B. indica*	2	3	R	LC	GL, US
Eulipotyphla Soricidae	House Shrew	*Suncus murinus*	3	9	R	LC	GL
Primates Cercopithecidae	Rhesus Macaque	*Macaca mulatta*	2	253	VC	VU	T

Table 3. List of wildlife (Amphibia to Mammalia) observed in the urban Dhaka megacity. (n: Frequency of Occurrence, RA: Relative Abundance, VC: Very Common; C: Common, UC: Uncommon, R: Rare, LC: Least Concern, NT: Near Threatened, VU: Vulnerable, DD: Data Deficient, GL: Grassland, PW: Permanent Waterbody, TW: Temporary Waterbody, RS: Roadside, US: Urban Settlement, T: Tree).

than in the earlier study. But, we have two new locality distribution records for amphibian species (Kalasgram Skipper Frog and Yellow Striped Frog) not previously reported by Reza & Perry (2015). We also recorded four frog species in the city under the genus *Fejervarya,* among six recorded across Bangladesh.

Reptiles were the least observed wildlife, found only in eight sites among the eleven surveyed. Among the reptiles, the highest species diversity was found for the family Gekkonidae (21%, 4 species). As for species compositions, almost half of the species were snakes (47.4%, 9 species) and the rest were lizards and turtles. More importantly, this study found two species of venomous snakes (Monocled Cobra and Binocled Cobra) in the grassland. No other published reports about herpetofauna in Dhaka city are available. This study found 31 species of herpetofauna. However, Reza & Perry (2015) found 31 species of amphibians and reptiles in the Jahangirnagar University Campus (Savar), a neighboring location of Dhaka city. They reported Ornate Flying Snake, Wall's Bronzeback, Bowring's House Gecko, Diard's Blind Snake, Jerdon's Blind Snake and Streaked Kukri Snake, which were not observed at our study sites. On the other hand, we recorded new species distribution for seven reptiles (White-spotted Supple Skink, Monocled Cobra, Roofed Turtle, Common Wolf Snake, Common Blind Snake, Common Bronzeback Tree Snake and Checkered Keelback).

Species diversity of birds was the highest for the family Ardeidae (8%, 13 species). The order Passeriformes was the most diverse order representing 72 species of birds. This study recorded some rare species that usually occur in forests, such as the Crested Serpent Eagle, Alexandrine Parakeet, Plum-headed Parakeet, Red-breasted Parakeet, Lesser Racket-tailed Drongo, Ashy Woodswallow,

Large Woodshrike, Red-whiskered Bulbul, Green-billed Malkoha, Lesser Coucal, Collared Scops owl, Orange-breasted Green Pigeon, Green Imperial Pigeon and Grey-capped Emerald Dove. This is possible because these rare birds were recorded from peripheral habitats of Dhaka megacity and the Mirpur National Botanical Garden. NBG is a protected area of the Bangladesh Forest Department that is regulated by the Bangladesh Wildlife (Conservation and Security) Act, 2012 that probably facilitates the presence of many species of wildlife, particularly forest birds. It is understood that birds can move easily between habitats, so they prefer to aggregate in such habitats where food and nesting trees are available. Our results suggest that the regional abundance of birds depends heavily on areas in which the traditional landscape and vegetation remain relatively intact. In addition, we also assumed that these forest birds may migrate from neighboring protected areas like Bhawal National Park and Modhupur National Park, about 20 km and 50 km away from Dhaka city, respectively, while flying over the Dhaka city.

Birds were seen easily in all study sites. This may be because some species prefer to colonize homestead urban habitats, for example, the Common Myna, House Crow, and Oriental Magpie Robin. In some study sites such as the Dhaka University campus, Ramna park, Uttara and Mirpur were represented by many species of birds. Uttara represented diverse habitats that were less disturbed and utilized by some important species of bird as foraging sites. We observed 34 species of birds in Shahbag near the Dhaka University campus. In the same study site, Akash et al. (2013) found 50 species and Chowdhury et al. (2014) found 78 species. We also observed 34 species of birds in Ramna park where Rajia et al. (2015) previously found 50 species. Avian richness in Shahbagh and Ramna has decreased from previous years, probably due to the impact of anthropogenic factors (e.g. pollution, construction work, human pressure). In Uttara study site, we found 125 species of birds, but Sarker et al. (2009) reported only 27 species from 2 out of 17 sectors of Uttara. In Uttara, particularly in Diabari (a fragmented place of Uttara), there are many planted trees, which enrich the homestead forests, and some fallow lands, grasslands and aquatic bodies including ponds that provide suitable habitats for wildlife. The diversity of avifauna has been decreasing gradually in most of the locations of Dhaka

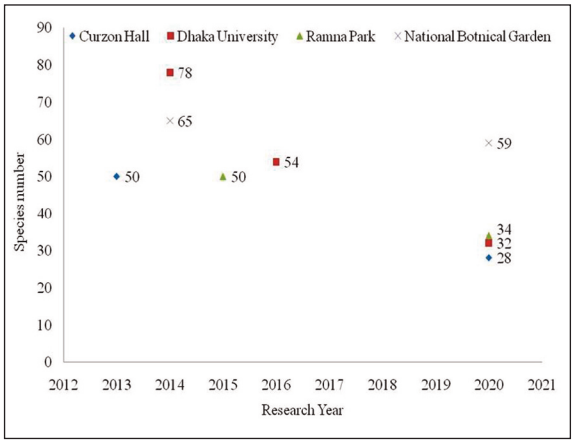

Figure 5. Trends of avifauna in the urban Dhaka megacity, present Study - Curzon Hall, Dhaka University, Ramna Park and National Botanical Garden; Akash et al. (2013); Chowdhury et al. (2014); Islam et al. (2014); Rajia et al. (2015); Banu et al. (2016).

city, particularly on the Dhaka University Campus (Fig. 5). However, this study recorded 24 colonies for bird species not reported before.

Among mammals, one-third of the total mammalian species were under the order Carnivora (37.5%, 6 species) followed by the order Rodentia (25%, 4 species). Mammalian fauna, especially the Flying Fox (47.8%, 417 indiv.), was frequently found in Dhaka city, particularly in the Ramna park area; almost half of the observed mammalian individuals. Ramna park is the only site where large fruiting, resting and roosting trees are available, which facilitate Flying Fox to roam inside the park. Furthermore, Ramna park is managed and protected by the local administration, which might be the reason for the highest number of bats being sighted there. Urban habitats of Dhaka have a few patchy areas that can support urban mammals. We found some small mammals like the Common Mongoose, Five Striped Palm Squirrel in Old Dhaka. These small mammals are well adapted in urban habitats and use bushes and trees to hide. The habitat of Old Dhaka is suitable for these small mammals. We also found that the Gangetic River Dolphin occurred in Buriganga river near Bosila and that the Jungle Cat and Golden Jackal were only found in the riverside of Buriganga. Buriganga is connected with the Meghna river via Dhaleswari which is used by the Gangetic River Dophin (IUCN Bangladesh, 2015). The riverside bushy areas are the ideal habitat for Jungle Cat and Golden Jackal. The other study

sites which we studied did not include this type of combined habitat hence they are seen here. We found a non-human primate, Rhesus Macaque in Gandaria within the Old Dhaka site.

Diversity indices

Diversity indices are important tools for priority settings to conserve species. The Shannon-Wiener index of diversity showed the species diversity of different study sites. Species diversity was rich in the sites where enriched floral diversity near the homestead and many waterbodies were present. Species richness is used in the similarity index to avoid species abundance to compare common species found in two sites. The highest number of shared species was found for Mirpur-Uttara (n = 48) and the lowest number was found in Demra-Gulshan areas. The habitat types in Mirpur and Uttara are similar to some extent (Table 1). For this reason, similarity was the highest for these sites indicating similar characteristics or closely related types of habitats supporting those urban wildlife species. This may be true because urban green spaces have been found to greatly influence species colonization and persistence rates (Gallo et al., 2017). In addition, 'Island Theory' may be applicable for explaining our species richness results. For example, Mirpur and Uttara sites, like islands were less complex and more numerous than larger ecosystems. However, we have less opportunity to explain our data on species richness under this theory since the current study was conducted on a terrestrial ecosystem. Interestingly, Uttara and Mirpur, both larger-sized sites in our study area, have characteristics of larger islands, harboring more species than smaller sites like Demra and Gulshan, and Mohammadpur and Demra had fewer species and were more isolated from other sites. Our data about these species richness has been supported by the prediction of MacArthur & Wilson (2001) that insular species richness depends on island size and isolation from source regions.

Habitat and substrate utilization

The Common Tree Frog and Yellow Stripped Tree Frog were found in some trees. This means that urban trees may support some arboreal amphibians. The Common Tree Frog and Yellow Stripped Tree Frog were observed at man height layer and all other species were seen using the ground layer of gardens and patchy habitats such as grassland, permanent waterbodies like ponds and rivers, temporary waterbodies like canals and drains, roadside vegetation and urban settlements. Reptilian species were found in arboreal habitats except for the Checkered Keelback and Striped Keelback, which were found in permanent as well as temporary waterbodies. The Indian Flap-Shell Turtle and Indian Roofed Turtle were found in temporary waterbody. Since reptilians are cryptic they change their habitats more frequently than others. In addition, reptilian diversity is known to be the lowest in urbanized areas for several reasons (Gibbon et al., 2000; Mitchell et al., 2008; Todd et al., 2010). This supports our results that reptiles may not prefer urban and disturbed habitats.

Birds used homestead trees, grasslands, even waterbodies for feeding, breeding and also to protect their territory. They were found in all types of layers from the ground level to the upper canopy. The Asian Palm Swift, Black Kite and House Swift were observed flying in all the study sites.

The highest species richness for mammals was found in terrestrial habitats, which includes grasslands, urban settlement and roadside vegetation. Squirrels, shrews, bats and macaque used different canopy layers because of their arboreal and aerial adaptations. Mammals are more susceptible than birds to the physical barriers that characterize the urban matrix, such as roads, buildings, artificial waterways, and increased human activity (Crooks, 2002; McKinney, 2006; Ordeñana et al., 2010).

Identification of anthropogenic threats

Unmanaged sewage systems and waste dumping pose serious threats to most wildlife habitats. We found that industrial and household polluted water were being directly discharged into city lakes, ponds, canals and nearby rivers without any treatment. Wastes materials such as plastics, polythenes, styrofoam food boxes, chips packets and other garbage were found disposed of openly in aquatic and terrestrial habitats. We identified construction works in progress that was potentially destroying wildlife habitat and hampering the migration route of different species. Random vehicle movements, use of parks and gardens as

a short passageway were also identified during the study period. Previous studies also identified pollution, mismanagement of waste materials, drainage problems as threats for Dhaka city (Hasan & Mulamoottil, 1994; Ahmad, 2009; Alom & Khan, 2014). These factors are known to adversely impact wildlife populations in urban communities (Emlen, 1974). Especially amphibians and other aquatic species are most likely to be affected as new infrastructure fills existing aquatic habitats and cut-off linkages between aquatic habitats. Thus, normal breeding activities of wildlife may be hampered due to such anthropogenic disturbances.

In conclusion, urban and suburban habitats are becoming increasingly important to biodiversity conservation efforts. This is obvious, as this study found rich vertebrate wildlife diversity, including some rare forest birds in the urban habitat. Natural habitats for wildlife in the urban Dhaka megacity have gradually been damaged (Banu et al., 2016, Akash et al., 2018), consequently, urban areas possess a great potential for being considered as future conservation areas (Magle et al., 2012). This study suggests that further research is important to understand how and which anthropogenic factors affect wildlife in the Dhaka megacity. Similarly, city architects and city administration need to understand the ecological effects of urbanization and make plans in line with protecting urban biodiversity.

In closing, we would like to encourage urban planners, decision-makers, ecologists and wildlife biologists to work together to formulate conservation plans to protect the urban wildlife and to make an eco-friendly urban megacity that is good for both humans and wildlife.

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