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Research Article

Species composition and classification of guilds in birds with respect to food and feeding behavior: Evidences from suburban landscape in Hooghly district, West Bengal

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ABSTRACT

Birds act as indicator of habitat quality as they respond to alterations in habitat structure and represent different trophic groups or guilds. Feeding guild in a bird community is determined by the varieties of food consumed, food procurement methods and foraging substrates exploited by respective bird species. The current study was carried out in Serampore, a suburban town situated on the west bank of river Hooghly in West Bengal. This study provides an insight into the bird-habitat relationship and foraging behaviour of birds based on their community structure. Biweekly sampling was carried out at the sampling site using fixed-radius (25m) point count method for a period of 10 minutes at randomly selected points to note the occurrence of avifauna. Based on the primary and pre-dominant food type, the foraging layers in the suburban habitat were classified as arboreal, terrestrial, and understory. The observations of the present study revealed 48 bird species, which belong to 12 orders and 25 families. The highest bird diversity (H′winter= 3.18) was recorded in the post winter months. The local status survey revealed that 18.75% species were rare, 33.3% common and 25% fairly common. The observed species were then categorised into 32 feeding guilds based on their food preferences.24.53% preferred insects and immature including caterpillars and grubs while 36.48% species were found to be carnivorous. Aquatic-insectivore-carnivore feeding guild was found to hold the maximum species followed by arboreal-terrestrial-insectivore and terrestrial-frugivore-insectivore guild respectively. As per the results, the suburban area under study not only proved to be a preferable and potential bird habitat but also a suitable foraging site for a wide array of bird species. Thus, the present study pertaining to the estimation of bird diversity and further exploration into their respective feeding guilds is expected to provide first-hand information for framing appropriate strategies for bird conservation in the landscape under study and other similarsuburban landscapes.

Key words: Suburban, point count, avian diversity, feeding guild

INTRODUCTION

Bird as a taxa has high potential to act as a surrogate for framing landscape level management plans as they are highly sensitive to erratic changes in an around their habitat. (Canterbury *et al*., 2000; Lindenmayer *et al*., 2000).The distribution, occupancy and resource use patterns in birdshave been severely affected by increased exploitation of natural resources (Chettri *et al*., 2001). It thus,becomes increasingly important to relate bird communities to their functional groups so as to have a better understanding of their relationships with such habitat alterations.

Segregation of bird species into different feeding guilds is considered to be one of the main measures adopted by respective species to coexist in a competitive environment (Root, 1967). Focus on choices of food in different bird species, respective food procurement methods and preferences of foraging heights and substrates,provide important information on the feeding guilds of birds (MacNally, 1994). Hence, the data derived from the above food exploitation patterns in birds provides an insight into the avian community organization by comparing bird communities within and between habitats(Rosenberg, 1990; Gokula& Vijayan, 2000).

The study of bird diversity and feeding guilds can reflect changes in the habitat under study. Further analysis of such data can help in identification of factors that alters the bird diversity and population dynamics of the surrounding area. It further provides an understanding of the guilds that are more sensitive to such changes. The study of guilds seems to be less time-consuming than that of individual species (Bell *et al*., 1986).Educational areas in urban and semi-urban setups attract a number of resident and migratory bird species and proves to be ideal spots for conducting avifaunal studies (Grimmett&Inskipp, 2007).

On this very backdrop, the present study was carried out in the suburban town of Serampore, district Hooghly, West Bengal, to assess the abundance and diversity of resident birds as well as to identify their respective feeding guilds. Direct measures of diet are rarely attempted hence, little is known about the habitat

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variation in species' diet with special reference to the avifaunal guilds along the Gangetic plains of West Bengal (Sengupta *et al*., 2014; Dubey *et al*., 2015; Mukhopadhyay & Mazumdar, 2017). The present study was aimed to provide foraging information in order to produce a guild classification for birds in a specific area at a primary level. Obtaining information about the methods in which birds exploit resources within a habitat patch would increase our understanding of their habitat usage patterns and the requisites for their survival. The results are expected to cater first-hand information on bird-habitat relationship and foraging behaviour of birds based on community composition. This could help in framing appropriate conservation strategies by highlighting the significance of maintaining suitable habitats in the suburbs.

MATERIAL AND METHODS

Sampling site and period of Sampling

The study was conducted inSerampore (22° 74' 88" N, 88° 35' 46"E) along the banks of river Hooghly. The vegetation of the study landscape comprised of naturally growing bushy shrubs, herbs, climbers, small grasses and large trees. The average annual precipitation of the study area amounts to 1,683 mm, the maximum and minimum temperature varies from 26.4°C -31.8°C in summer, to 10°C -19°C in winter; the relative humidity differs between 94% and 65%. The present study was carried out for a period of 6 months between December and May for three consecutive years (2017-2019).

Sampling protocol

The sampling site was visited twice every week from December to May (2017-2019). Avifaunal surveys were conducted thrice a day- morning (between 0700 h and 1000h), noon (between 1100h and 1400h) and afternoon (between 1500h and 1700h/1730h, depending on the sunset time), by the help of binoculars (Olympus 8-16x40 ZOOM DPS I). Fixed-radius (25m) point count method was applied for recording the avifaunal diversity at individual count locations. The point count method was used for a duration of 10 minutes at randomly selected locations at least 100m apart in a 360° arc and all observations were performed in the forward direction of movement. However to prepare a comprehensive checklist of the study area, opportunistic observations of birds were also made other than sampling period. Rainy and windy days were strictly avoided. The same survey protocol was followed in all the seasons. For evidential documentation, the photos of the birds were captured in a digital camera (CANON 700D).

There were cases where the same species of bird was noticed to feed on two different food items, viz. Spotted dove *Spilopelia chinensis* fed predominantly on grains and seeds but also on fruits at times, but it was classified as grainivorous. This approach is consistent with the classifications used by Canaday,1997; Wells,2007. Field foraging observations were made during the sampling period from December to May (2017-2019). Four observation points were used for each location. Flock and individual bird movements were considered during switching between observation points to avoid recollection of information on the same individual. Several consecutive observations of the same individual were avoided since they are subjected to temporal autocorrelation.

Data collection

During the present study every possible effort was made to identify the foraging layer of the bird studied. For this, the forage layers in suburban habitat were classified as: Arboreal >10 m, terrestrial, understory 0-10 m following Grimmett *et al*. (2011). Feeding guilds were classified as per direct observations and available literatures (Ali, 1996). The feeding guilds were determined according to the primary and predominant food type. The observed bird species were categorized into seven guilds, namely, carnivore (Car), omnivore (Omn), frugivore (Frug), herbivore (Herb), nectarivore (Nect), granivore (Gran) and insectivore (Ins).

Identification

The birds were identified using bird field guide by Grimmett *et al*. (2011). For nomenclature of the birds, that included order, family, common name and scientific name Inskipp *et al*. (1996) was followed.

Data analysis

The Shannon diversity index was applied for estimation of species diversity across the sampling months (Shannon & Wiener, 1949). This index was calculated by the equation $H' = -\Sigma p_i \ln p_i$ and Shannon Hmax [$H_{max} = \ln(S)$], where p_i is the proportion of individuals found in the i-th species, S denotes the number of species and 'ln' denotes the natural logarithm. Shannon evenness was calculated using the formula, $J = H'/H_{max}$ (Magurran, 1988). Species dominance across habitats was estimated by Simpson's dominance index (Simpson, 1949). The diversity indices of the bird abundance of each habitat were analyzed separately using BioDiversity Pro software (McAleece *et al*.,1997).

Based on seasonal dispersal pattern, birds were classified as resident (R), summer visitor (SV), winter visitor (WV) or passage migrant (P), followingGrimmett *et al*. (2011). A local status was also assigned to each species following (Khan &Naher, 2009), where very common (Vc) bird species were recorded on 80–100% of field visits, common (Co) species on 50–79% of field visits, fairly common (Fc) on 20–49% of field visits and rare (Ra) on less than 20% of the field visits. The IUCN Red List was referred for the conservation status of birds and their global population trend (del Hoyo *et al*., 2016; IUCN, 2021).

To comment on the variation in the abundance of bird species with respect to the sampling seasons and sampling time, data was subjected to three way factorial ANOVA. Similar analysis was applied with the data on individual feeding guild, to test the effect of types of food, bird species and sampling seasons. To infer about the variation between the sampling seasons and time, post-hoc *Tukey test* was applied. The statistical analyses were performed following Zar(1999) using the SPSS version 11 (Kinnear & Gray, 2000).

RESULTS

Depending on the availability of different food types, the observations of the present study carried out between December and May (2017-2019) revealed 48 species of birds belonging to 25 families (Table 1). Members of families Sturnidae and Ardeidae were found to be the most abundant followed by Megalaimidae, Alcedinidae and Corvidae. The highest number of bird species belonged to the order Passeriformes with

Table 1. List of birds, their respective families observed during the study period of December to May (2017 – 2019) along with the abbreviations used, respective taxonomic positions (order, family), dispersal status (R – resident, WV – winter visitor, SV – summer visitor, P – passage migrants), IUCN status (LC-Least Common, NT- Near Threatened), local status (Vc – very common, Co – common, Fc – fairly common, Ra – rare), and global population trend (Dec. – declining, Inc. – increasing. Stable – sta-

Sl. No.	Common Name	Scientific name	Family	Order	Abbrevia-tions	IUCN Status	Local status	Global trend
1	Alexandrine Parakeet	*Psittaculaeupatria*	Psittaculidae	Psittaciformes	ALP	NT	Ra	Dec.
2	Rose-ringed Parakeet	*Psittaculakrameri*	Psittaculidae	Psittaciformes	RRP	LC	Vc	Inc.
3	Asian Koel	*Eudynamysscolopaceus*	Cuculidae	Cuculiformes	AKL	LC	Vc	Stable
4	Asian Palm Swift	*Cypsiurusbalasiensis*	Apodidae	Caprimulgiformes	APS	LC	Vc	Stable
5	Black crowned night Heron	*Nycticoraxnycticorax*	Ardeidae	Pelecaniformes	BNH	LC	Ra	Dec.
6	Indian Pond-Heron	*Ardeolagrayii*	Ardeidae	Pelecaniformes	IPH	LC	Vc	Unknown
7	Intermediate Egret	*Ardea intermedia*	Ardeidae	Pelecaniformes	IEG	LC	Fc	Dec.
8	Black Kite	*Milvus migrans*	Accipitridae	Accipitriformes	BKT	LC	Vc	Unknown
9	Black-rumpedFlameback	*Dinopiumbenghalense*	Picidae	Piciformes	BRFL	LC	Co	Stable
10	Blue-throated Barbet	*Psilopogon asiaticus*	Megalaimidae	Piciformes	BLBR	LC	Co	Stable
11	Cattle Egret	*Bubulcus ibis*	Ardeidae	Piciformes	CEG	LC	Vc	Inc.
12	Common Kingfisher	*Alcedoatthis*	Alcedinidae	Coraciiformes	CKN	LC	Fc	Unknown
13	Green Bee-eater	*Meropsorientalis*	Meropidae	Coraciiformes	GBE	LC	Fc	Increasing
14	Stork-billed Kingfisher	*Pelargopsis capensis*	Alcedinidae	Coraciiformes	SKN	LC	Ra	Dec.
15	White-throated Kingfisher	*Halcyon smyrnensis*	Alcedinidae	Coraciiformes	WKN	LC	Co	Inc.
16	Common Sandpiper	*Actitishypoleucos*	Scolopacidae	Charadriiformes	CSN	LC	Fc	Dec.
17	Coppersmith Barbet	*Psilopogonhaemacephalus*	Megalaimidae	Piciformes	CPBB	LC	Co	Inc.
18	Eurasian Wryneck	*Jynx torquilla*	Picidae	Piciformes	EWR	LC	Ra	Dec.
19	Lineated Barbet	*Psilopogonlineatus*	Megalaimidae	Piciformes	LNBR	LC	Fc	Stable
20	Greater Coucal	*Centropus sinensis*	Cuculidae	Cuculiformes	GCL	LC	Fc	Stable
21	Little Cormorant	*Microcarboniger*	Phalacrocoracidae	Suliformes	LCR	LC	Co	Unknown
22	Spotted Dove	*Streptopelia chinensis*	Columbidae	Columbiformes	SDV	LC	Co	Inc.
23	Yellow-footed Green Pigeon	*Treronphoenicopterus*	Columbidae	Columbiformes	YGP	LC	Vc	Inc.
24	White-breasted Waterhen	*Amaurornisphoenicurus*	Rallidae	Gruiformes	WWH	LC	Fc	Unknown
25	White-browed Wagtail	*Motacillamaderaspatensis*	Motacillidae	Passeriformes	WBWG	LC	Ra	Stable
26	White browed Fantail	*Rhipiduraaureola*	Rhipiduridae	Passeriformes	WFN	LC	Ra	Stable
27	White wagtail	*Motacilla alba*	Motacillidae	Passeriformes	WWG	LC	Fc	Stable
28	Oriental Magpie-Robin	*Copsychussaularis*	Muscicapidae	Passeriformes	OMR	LC	Co	Stable
29	Pale billed Flowerpecker	*Dicaeumerythrorhyrchos*	Dicaeidae	Passeriformes	PBFW	LC	Ra	Stable
30	Plain Prinia	*Priniainornata*	Cisticolidae	Passeriformes	PPR	LC	Ra	Stable

Table 1. *Continued*

31	Purple Sunbird	*Cinnyris asiaticus*	Nectariniidae	Passeriformes	PSN	LC	Co	Stable
32	Purple-rumped Sunbird	*Leptocomazeylonica*	Nectariniidae	Passeriformes	PRSN	LC	Fc	Stable
33	Red-vented-Bulbul	*Pycnonotuscafer*	Pycnonotidae	Passeriformes	RVBL	LC	Vc	Stable
34	Red-Whiskered-Bulbul	*Pycnonotusjocosus*	Pycnonotidae	Passeriformes	RWBL	LC	Fc	Dec.
35	Rufous Treepie	*Dendrocittavagabunda*	Corvidae	Passeriformes	RFT	LC	Co	Stable
36	Jungle Babbler	*Turdoides striata*	Leiothrichidae	Passeriformes	JNBB	LC	Co	Stable
37	Jungle Myna	*Acridotheresfuscus*	Sturnidae	Passeriformes	JNMY	LC	Co	Dec.
38	Large-billed Crow	*Corvus macrorhynchos*	Corvidae	Passeriformes	LBC	LC	Co	Stable
39	House Crow	*Corvus splendens*	Corvidae	Passeriformes	HCW	LC	Vc	Stable
40	Indian Golden Oriole	*Orioluskundoo*	Oriolidae	Passeriformes	IGO	LC	Ra	Unknown
41	Common Tailorbird	*Orthotomussutorius*	Cisticolidae	Passeriformes	CMT	LC	Co	Stable
42	Chestnut-tailed Starling	*Sturniamalabarica*	Sturnidae	Passeriformes	CTS	LC	Fc	Unknown
43	Citrine Wagtail	*Motacillacitreola*	Motacillidae	Passeriformes	CWG	LC	Fc	Inc.
44	Common Myna	*Acridotheres tristis*	Sturnidae	Passeriformes	CMY	LC	Vc	Inc.
45	Asian Pied Starling	*Gracupica contra*	Sturnidae	Passeriformes	APS	LC	Co	Inc.
46	Barn Swallow	*Hirundo rustica*	Hirundinidae	Passeriformes	BSW	LC	Co	Dec.
47	Black Drongo	*Dicrurusmacrocercus*	Dicruridae	Passeriformes	BDR	LC	Vc	Unknown
48	Black-hooded Oriole	*Oriolusxanthornus*	Oriolidae	Passeriformes	BHO	LC	Co	Unknown

(24 species), followed by the order Piciformes having (five species), further followed by Pelecaniformes and Coraciformes each having(four species). Evaluation of local abundance showed that nine species (18.75%) were rare, 12 species (25%) were fairly common, 11 species (22.91%) were very common and 16 species (33.34%) were common. Interestingly enough, it was found that nine species with a global declining trend (del Hoyo *et al*., 2016) were found to be very common in the studied landscape. (Table 1). Again Alexandrine Parakeet, *Psittaculaeupatria,* which is 'Near Threatened' (IUCN, 2021) was also observed in good numbers.

Variation with respect to abundances of the bird species was prominent across the sampling seasons (winter, post-winter, summer) and sampling time (morning-noon-afternoon) (Figure 1).

Post winter months were noted to have highest diversity (H'_{winter}= 3.18) as compared to winter and summer months (Table 2). Results of three way factorial ANOVA on the abundance of bird species with respect sampling seasons and time also supported the observed seasonal variation (Table 3). *Post-hoc Tukey* test between sampling seasons and time also revealed significant variation in all the cases, suggesting the contributory impact of seasons and sampling time over the abundance of bird species (Table 4).

Table 2. Values of Shannon and Wiener diversity index (H′), Shannon richness (Hmax) and Shannon evenness (J) for the bird species observed across the different sampling seasons during the survey period.

Indices	Winter	Post winter	Summer
H′	2.95	3.18	3.16
H_{max}	3.50	3.64	3.58
H_{even}	0.84	0.87	0.88

All the observed species were categorized into 15 feeding categories (Table 5). Majority of avian species studied (N= 54), were found to prefer various plant matters such as flowers, fruits, nectars, grains, seeds and vegetables. 24.53% were noted to feed on insects and immature including caterpillars and grubs within the study landscape while 36.48% species were found to be carnivorous (Figure 2).

The entire 48 species of birds were categorised into 32 feeding guilds based on their preferable feeding niches (Table 6). Aquatic-insectivore-carnivore feeding guild house the maximum species (N=4) followed by arboreal-terrestrial-insectivore, terrestrial frugivore insectivore and terrestrial insectivore (N=3) [Table 6 and Fig. 3(A-D)].

Results of three-way factorial ANOVA on the occurrence of feeding guilds of bird species taking into consideration the food types, species, sampled months and sampling time as predictor variables, revealed significant variation suggesting that the food types had a considerable effect on the occurrence of the bird species (Table 8).

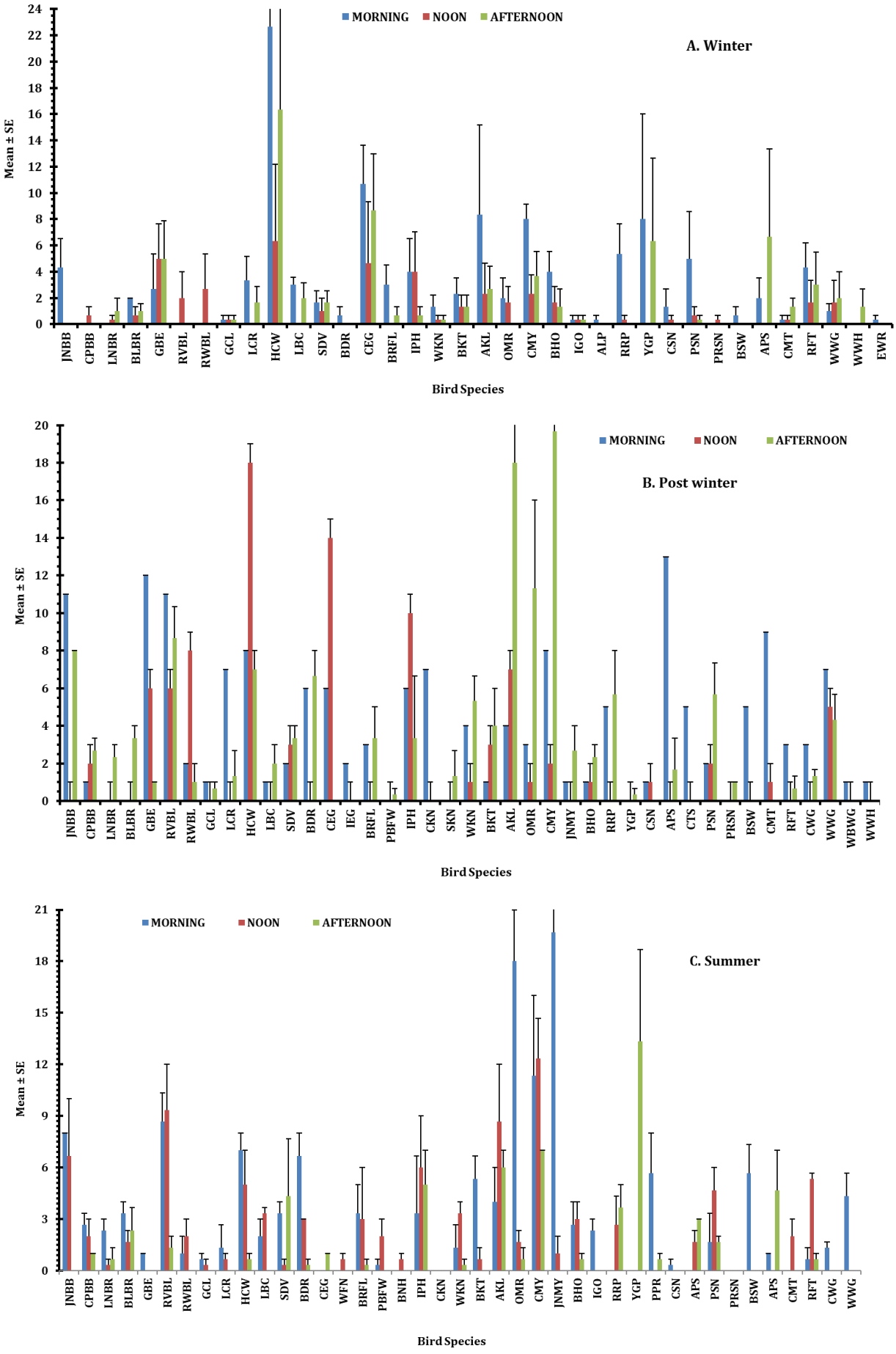

Figure 1. Variation in abundances of different species of birds as observed across the study period of December to May (2017 – 2019) during morning, noon and afternoon. Birds that were at least cited once during the sampling period are only represented here.

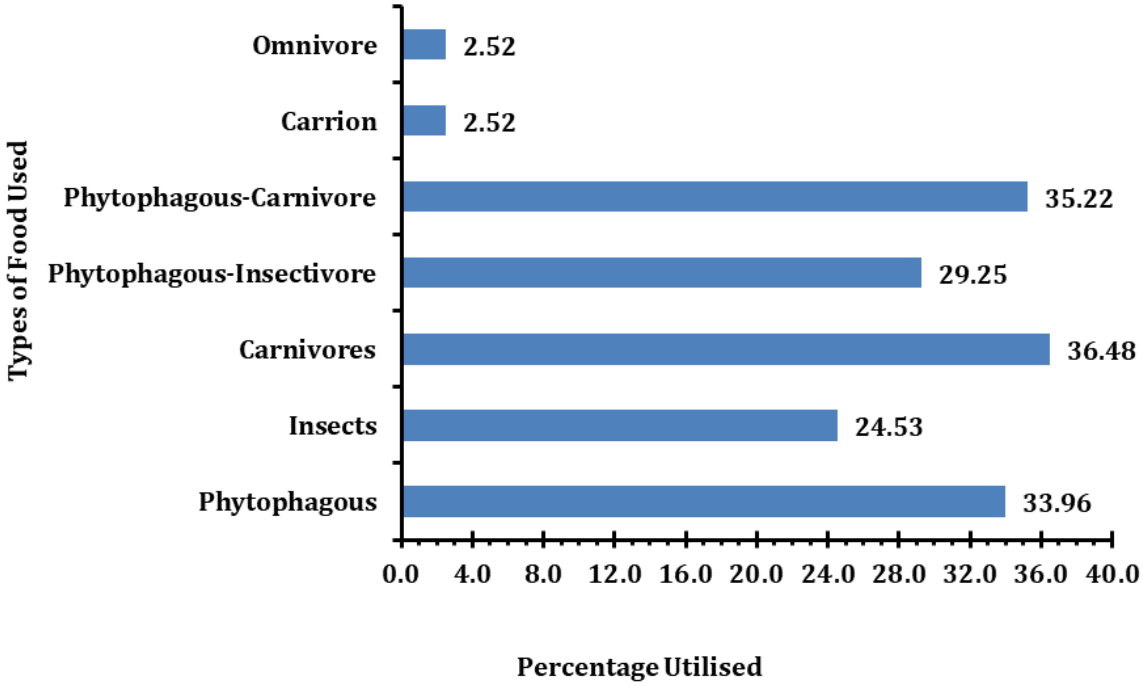

Figure 2. Proportion of bird species based on their feeding guilds. Numbers indicate the percentage utilised by respective feeding categories of birds

Table 3. Results of three-way factorial ANOVA on the abundances of bird species considering the species, sampled seasons and sampling time as predictor variables. All *F* values are significant at P <0.05 level.

Source	Sum of Squares	df	Mean Square	*F*
Species (SP)	7345.26	47	156.28	**30.77**
Season (S)	440.67	2	220.33	**43.38**
Time (T)	485.22	2	242.61	**47.76**
SP * S	3864.44	94	41.11	**8.09**
SP * T	5114.33	94	54.41	**10.71**
S * T	189.70	4	47.42	**9.34**
SP * S * T	6814.75	188	36.25	**7.14**
Error	4388.67	864	5.08	
Total	28643.03	1295		

Table 4. Results of Post hoc Tukey test between sampling seasons (A) and time (B). Studentized range q = [|(I-J) |/S.E]. Values marked bold are at P <0.05 level. In both the cases, S.E. = 0.15

(I) Season	(J) Season	q
Winter	Post winter	**1.43**
Winter	Summer	**0.64**
Post winter	Summer	**0.78**

(I) Sampling time	(J) Sampling time	q
Morning	Noon	**1.48**
Morning	Afternoon	**0.94**
Noon	Afternoon	**0.54**

Table 5. List of variety of food items on which the bird species are dependent as observed during the study period.

FOOD ITEMS	Number of Species	Percentage of species
Grains and Seeds	9	5.66
Fruits and Berries	22	13.84
Flower	5	3.14
Nectars	15	9.43
Vegetables	3	1.89
Grubs and Caterpillar	3	1.89
Insects	36	22.64
Fish	11	6.92
Toads and Frogs	8	5.03
Reptiles	10	6.29
Eggs and Youngs of Birds	6	3.77
Small Mammals (Rodents)	5	3.14
Carrion	4	2.52
Macroinvertebrates (other than insects)	18	11.32
Refuge around Human habitation	4	2.52

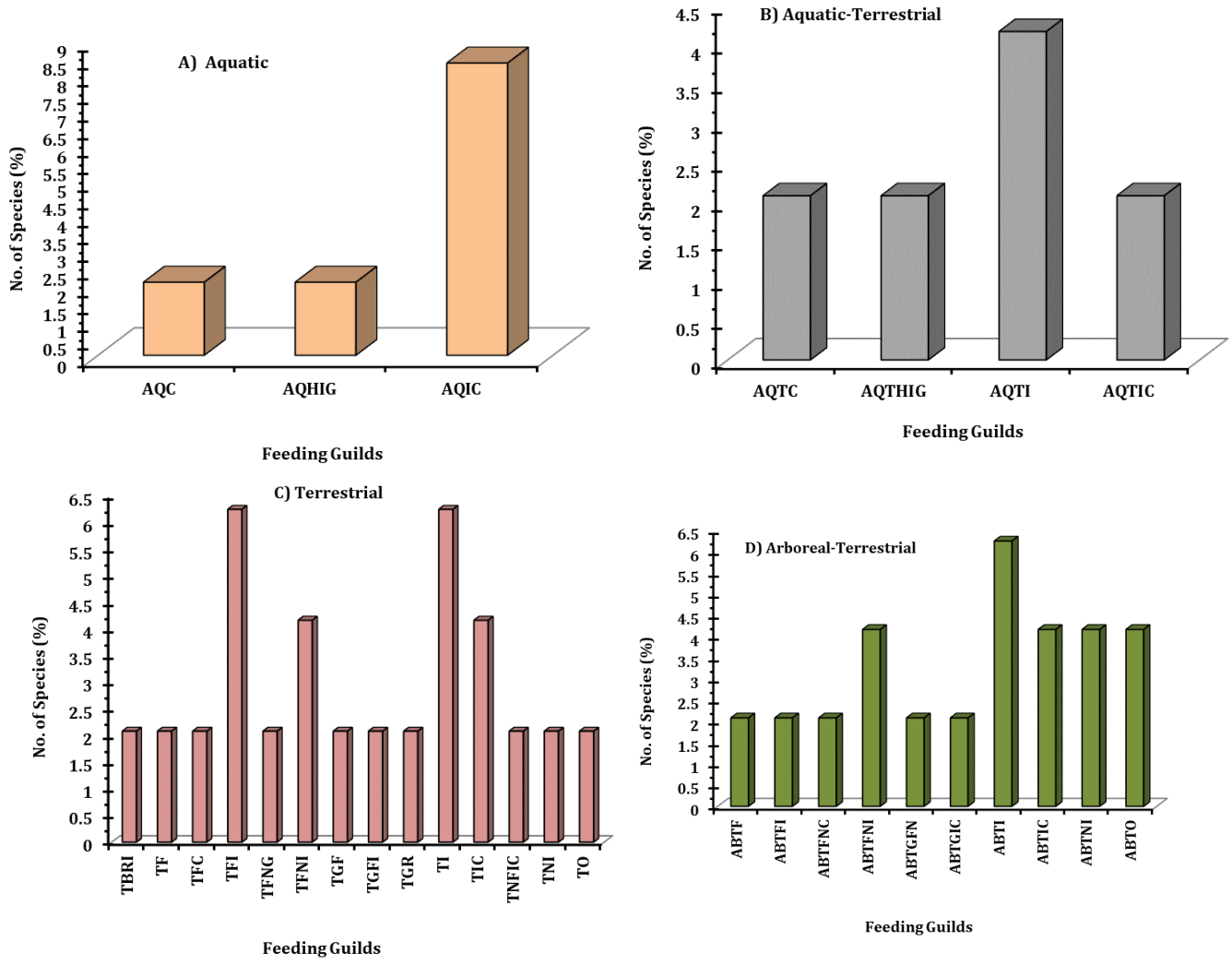

Figure 3. Species having diverse feeding guilds in various types of habitat preferences: A) aquatic B) aquatic-terrestrial, C) terrestrial habitat and D) arboreal-terrestrial

Table 6. Feeding guilds of the bird species observed during the study period in various habitats

Sl. No.	Feeding guild	Abbreviations used	Species of bird in respective preferable feeding niches
1	Arboreal-Terrestrial Frugivore	ABTF	Yellow-footed Green Pigeon
2	Arboreal-Terrestrial Frugivore-Insectivore	ABTFI	Asian Koel
3	Arboreal-Terrestrial Frugivore-Nectarivore-Carnivore	ABTFNC	Rufous Treepie
4	Arboreal-Terrestrial Frugivore-Nectarivore-Insectivore	ABTFNI	Coppersmith Barbet, Red-vented-Bulbul
5	Arboreal-Terrestrial Granivore-Frugivore-Nectarivore	ABTGFN	Rose-ringed Parakeet
6	Arboreal-Terrestrial Granivore-Insectivore-Carnivore	ABTGIC	Jungle Babbler
7	Arboreal-Terrestrial Insectivore	ABTI	Plain Prinia, White browed Fantail, Oriental Magpie-Robin
8	Arboreal-Terrestrial Insectivore-Carnivore	ABTIC	Black Kite, Eurasian Wryneck
9	Arboreal-Terrestrial-Nectarivore-Insectivore	ABTNI	Black Drongo, Purple Sunbird
10	Arboreal-Terrestrial Omnivore	ABTO	Common Myna, House Crow
11	Aerial Insectivore	AI	Green Bee-eater
12	Aquatic Carnivore	AQC	Little Cormorant
13	Aquatic Herbivore-Insectivore-Granivore	AQHIG	White-breasted Waterhen
14	Aquatic Insectivore-Carnivore	AQIC	Common Kingfisher, Common Sandpiper, Intermediate Egret, Inidan Pond-Heron
15	Aquatic-Terrestrial Carnitivore	AQTC	Stork-billed Kingfisher
16	Aquatic-Terrestrial-Herbivore-Insectivore Grraniovore	AQTHIG	White-browed Wagtail
17	Aquatic-Terrestrial Insectivore	AQTI	Citrine Wagtail, White Wagtail
18	Aquatic-Terrestrial Insectivore Carnovore	AQTIC	Cattle Egret
19	Terrestrial Bark probing Insectivore	TBRI	Black-rumpedFlameback
20	Terrestrial Frugivore	TF	Pale billed Flowerpecker
21	Terrestrial Frugivore Carnivore	TFC	Greater Coucal
22	Terrestrial Frugivore Insectivore	TFI	Black-hooded Oriole, Blue-throated Barbet, Indian Golden Oriole
23	Terrestrial Frugivore Nectarivore Granivore	TFNG	Purple-rumped Sunbird
24	Terrestrial Frugivore Nectarivore Insectivore	TFNI	Chestnut-tailed Starling, Re-Whiskered-Bulbul
25	Terrestrial Granivore Frugivore	TGF	Alexandrine Parakeet
26	Terrestrial Granivore Frugivore Insectovore	TGFI	Asian Pied Starling
27	Terrestrial Granivore	TGR	Spotted Dove
28	Terrestrial Insectivore	TI	Asian Palm Swift, Barn Swallow, Jungle Myna
29	Terrestrial Insectivore-Carnivore	TIC	White-throated Kingfisher, Black crowned night Heron
30	Terrestrial Nectarivore Frugivore Carnivore Insectivore	TNFIC	Lineated Barbet
31	Terrestrial Nectarivore Insectivore	TNI	Common Tailorbird
32	Terrestrial Omnivore	TO	Large-billed Crow

Table 7. Results of three-way factorial ANOVA on the occurrence of feeding guilds of bird species taking into consideration the food types, species, sampled months and sampling time as predictor variables. All *F* values are significant at P <0.05 level.

Source	Sum of Squares	df	Mean Square	*F*
Food Type (FT)	247.21	14	117.66	**5.87**
Species (SP)	5493.67	47	116.89	**5.78**
Season (S)	302.96	2	151.48	**7.49**
FT * SP	4613.01	411	111.22	**6.55**
FT * S	593.99	24	124.75	**11.22**
SP * S	2202.92	94	123.44	**11.16**
FT * SP* S	4608.51	332	113.88	**6.69**
Error	7424.42	367	20.23	
Total	25486.70	1295		

DISCUSSION

Cities hold a wide range of biodiversity in spite of the craze and rage of development and urbanisation. This puts into perspective as cities being landscapes having great potential for promotion and conservation of biodiversity, where sadly biodiversity faces the greatest challenges to thrive (Farinha-Marques *et al*., 2015).

48 species of birds were recorded during the present study which indicated that Serampore and similar other suburban areas provide congenial biotope to attract birds as well vis-a-vis were suitable foraging sites for a wide array of bird species. The rich avian assemblage of this suburban area reflects possible variation in their functional roles, feeding habits and resource utilization patterns. Urban sites holds a greater proportion of avian species that are multiple brooders, constructs nest on urban structures, feeds on seeds, year round residents and are non-territorial. In contrast, natural sites holds a greater proportion of individuals that are single brooders, nest in shrubs and snags, feeds on insects, migrates long distances and maintain territories during the breeding season. Suburban habitats are tipping points in the shift of avian communities from wilderness areas to exotic and homogeneous urban landscapes (Blair & Johnson, 2008; Da Silva *et al*., 2021).

The bird composition of a site depends on the vegetation structure of the landscape (Redich *et al*., 2018; Zhou *et al*., 2019). More the complexity of the vegetation in a particular landscape, higher is the diversity of the harbouring avian species of that area (Batisteli *et al*., 2018). In the context of the present study, presence of plentiful food resources such as dragonflies, wasps, beetles, homopterans, as well as appropriate shelter and nutrients in agricultural fields, orchards of mango, guava etc and kitchen gardens contribute towards the high species richness in the area (H_{max}post winter>summer>winter; in all cases H_{max}>3, Table 2). Suburban gardens are arguably becoming the main contributor of urban biodiversity in many developed countries (Sodhi *et al*., 2005; Chamberlain *et al*., 2007). Possibly presence of the river along the stretch of the study landscape contributed towards the occurrence of White-throated Kingfisher *Halyconsmyrnensis*, Cattle Egret *Bubulcus ibis* and White-browed Wagtail *Motacilla alba*. They feed on small fishes, arthropods, small crabs etc which were plenty in the adjoin river. House Crow *Corvus splendens* was found in highest abundance followed by Cattle Egret during winter. Common Myna*Acridotheres tristis* was found to be in highest abundance followed by House Crow and Asian Koel*Eudynamysscolopaceus* during post winter. Jungle Myna*Acridotheresfuscus* was found to be in highest abundance followed by Oriental Magpie Robin *Copsychussaularis* during summer. The result of the present study in terms avifaunal richness is comparable with several other ecosystems in West Bengal. 117 bird species belonging to 42 families were recorded from three different national parks and forest reserves in North Bengal (Dubey *et al*., 2015) and 86 species belonging to ten orders and 35 families was reported from a coastal area in Digha (Patra & Chakrabarti, 2014). Perhaps, the heterogeneity of habitats in the area under study contributed to diverse resource availability and hence, avifaunal richness. An indirect finding of the present study was the absence of House Sparrow *Passer domesticus* throughout the sampling period which was in parity with the findings of the studies conducted elsewhere in India (Ghosh *et al*., 2010), and round the globe (Behera & Mishra, 2019). This decline is so profound that the species had been categorized as a red data-listed species demanding immediate conservation concern (Gregory *et al*., 2002). Alexandrine Parakeet, *Psittaculaeupatria,* which has a IUCN status 'Near Threatened' (IUCN, 2021) was observed to be present in the suburban landscape which again highlights the importance of suburbs in conservation and maintenance of biodiversity.

The diet of a bird species represented a fundamental aspect of its ecological niche and dietary adaptations which played a crucial role in understanding its ecology and evolution. Food availability seemed to be integrally linked with abundance and diversity of bird species in any specific landscape(Prajapati *et al*., 2008). In the present scope of study, phytophagous dietary guild showed high dominance followed by that of carnivore and insectivore (Table 5-6, Fig. 2). The results were in consistence with other studies conducted in the Indian subcontinent (Johnsingh& Joshua, 1994; Bhatt & Joshi, 2011; Singh *et al*., 2018). It was evident that the different species of bird belonging to a particular feeding guild had evolved specialized feeding structure for habitat exploration. This aided them in obtaining food resources more efficiently and reduced competition within a guild (Ranawana & Bambaradeniya, 1998). To ensure their survival and optimize food resources, birds showed various foraging behaviours to exploit diverse food resources in suburbs that are directly related to the structural adaptations of each species i.e. structure of wings, legs and feet and bill.

In the backdrop of continuous encroachment of green cover to accommodate the load of human pressure, the suburban gardens are likely to become increasingly important for conservation and they are arguably the main contributor to urban biodiversity in many developing countries (Sodhi *et al*., 2005; Chamberlain *et al*., 2007; Da Silva *et al*., 2021), including India (Khera *et al*., 2009; Rathod *et al*., 2015) and West Bengal (Das & Das, 2016). Birds are good ecosystem service providers taking active role in seed dispersal, pollination, biological pest control and thus playing an important role in proper functioning of the ecological cycle. Thus, decline in the diversity of birds concomitant with the reduction in their feeding resources is a cause of major concern which in turn may have a surging effect on the food chain, thereby affecting numerous species and consequently disturbing the entire ecosystem balance. (Sekercioglu *et al*., 2004). Documentation of the species richness and composition of birds in a particular landscape through habitual surveillance is a prerequisite to assess its ecological importance and thereby defining the ecosystem health. The study landscape comprises of built-up areas standing tall along the banks of River Hooghly encompassing varied flora, vast uncultivated grazing pastures, and maintained backyard gardens. Habitat diversity in the study area plays a vital role in holding fairly high species richness. The present study noted the occurrence of nine species (Stork-billed Kingfisher, Black crowned night Heron, Intermediate Egret, Jungle Myna, Alexandrine Parakeet, Common Sandpiper, Red-Whiskered-Bulbul, Asian Pied Starling and Barn Swallow) having a global declining population trend and even one of them (Alexandrine Parakeet) being categorised under IUCN 'Near Threatened' group

(IUCN, 2021). The occurrence of these species in the study landscape indicates the presence of favourable resources in the area and thus long term monitoring of these species must be ensured. Further researches encompassing their ecological and behavioural aspects should be encouraged in the suburban backdrop keeping in view its trending importance..

Thus, conservation efforts should principally focus on minimising the effects of the anthropogenic disturbances to lessen their effects on avian functional diversity. Further, effective conservation assessment should emphasise novel approaches in order to explore the connection between disturbance, functional diversity and especially ecosystem function, through employment of multiple complementary indices (Matuoka *et al*., 2020).

The findings of the present study with respect to the respective feeding habits can be used for further ecological assessment with special reference to studies on population structure, habitat use, and foraging ecology in order to understand the crucial role they play to keep the entire ecosystem functional. Apart from regular monitoring of the birds, identifying the potential threats as well as appraisal of their species-specific roles in maintaining ecosystem health may also prove noteworthy to link the gap of existing knowledge on avifauna and nourishing the environmental reliability of this suburban backdrop.

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