Jagannath University Journal of Life and Earth Sciences, **9**(1): 19-44, 2023 (June) pISSN 2414-1402, eISSN 2791-1845
DOI: https://doi.org/10.3329/jnujles.v9i1.72838

Research Article JnUJLES

HETEROGENERIC DIVERSITY AND RICHNESS OF AVIFAUNA IN A DEGRADED LANDSCAPE OF ARIAL BEEL IN BANGLADESH

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Received: 01 January 2023, Accepted: 02 June 2023

ABSTRACT

Bird diversity and richness reflect the habitat quality of ecosystems. The species composition, diversity, and richness of birds were studied at Shologhar Union, a degraded landscape of Arial Beel, from March 2016 to February 2017, using line transect and point count methods. A total of 75 species of birds belonging to 14 orders and 35 families were recorded; most of them were residents (83%). Non-passerine birds were predominant (40 species, 53% of total species), with 18 families and 38 genera. Only one near-threatened species (Yellow Wattled Lapwing *Vanellus malabaricus*) was recorded. Among resident birds, Baya weaver (*Ploceus philippinus*) was dominant, and the Yellow Wagtail (*Motacilla flava*) was predominant among migratory birds. Most species were terrestrial (51 spp., 68% of total birds), contributing only 23% of the population. The individual rarefaction revealed the highest species richness in March and the lowest in May and June. The highest population was recorded in winter (38%), and insectivore species (40%) were the highest. No significant seasonal variation occurred in the richness of birds (Kruskal-Wallis test: K = 0.05 df = 2, p = 0.971) and in different feeding guilds (Kruskal-Wallis test: K = 0.86, df = 5, p = 0.65). Ardeidae and Sturnidae represented the highest diversified families (6 species in each, RDi = 8), and Baya Weaver contributed the highest (26%) population. The presence of different species of birds suggests that this site could provide a suitable habitat for wild birds, and restoration management of this part of Arial Beel should require conserving the habitat of avifauna.

Keywords: *Diversity, Richness, Status, Shologhar, Feeding guilds, Bangladesh*

Introduction

Bangladesh possesses enormous area of wetlands which are integral part of the local ecosystem. All these wetlands shelter extremely rich biodiversity which is an essential part of healthy ecosystem. Highly diverse biological components of wetlands provide extensive ecosystem services such as water purification, flood abatement and climate regulation (Zedler and Kercher, 2005; Lao *et al*., 2019). Wetlands degradation is perceived in Bangladesh due to various anthropogenic factors which subsequently decline wetland-dependent species (Sievers *et al.*,

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2018). Birds are good ecological indicators of the diversity of other animal groups and of habitat condition because they quickly respond to habitat changes (Chace and Walsh, 2006; Pellissier *et al*., 2012) and wetland birds are sensitive indicators of wetland conditions (Lao *et al*., 2019).

Arial Beel is one of the largest wetlands in Bangladesh and large depression of 136-square-kilometer (approximately), situated in between the Padma and the Dhaleshwari, River (Roy *et al*., 2022). During monsoon, this area is inundated by rainy water and protects the surrounding land from flood and during winter and summer this area is comprised of diversified physical features like ponds, marshes, jungles, agricultural lands, grassy and bushy areas and water was logged in some depression like ponds which are basically gold mines of local fishes (Roy *et al*., 2022). Seasonal changes of this physical feature attract different species of wild animals especially birds. Many wild animals use this area as nesting and feeding grounds. Arial Beel is expanded in two districts, four upazillas and 15 unions, most of the sites are degraded due to various anthropogenic activities such as conversion of wetlands to agricultural lands or form commercial fishing purposes, use of pesticides and insecticides, excessive fishing, unsustainable use of wetland resources, hunting and poaching. Shologhar union is one of the degraded parts of Areal beel. Assessment and monitoring bird population is crucial to understand the habitat quality since their numbers, distribution and activities reflect the ecosystem's health and status (Ismail *et al*., 2012). Seasonal fluctuations of birds, species richness and diversity link to the abundance of food resources (Lameed, 2011). Bird species diversity is, therefore, a good measure of the value of ecosystems (Dugan, 1990) and directly correlated with biological and structural features of habitat (Allen *et al*., 1999; Sritharan and Burgess, 2012).

Bird population is declining worldwide because of anthropogenic activities (Rapoport, 1993) and climate change (Chen *et al.,* 2011; Sekercioglu *et al.,* 2012). Urbanization creates biotic homogenization which replaces generalist bird species to diverse species (McKinney and Lockwood, 2001; Crooks *et al.,* 2004) and causing threats to many bird species globally (Pickett *et al.,* 2001; Hansen *et al.,* 2005). Developmental activities and urbanization is an alarming threat to many ecosystems especially wetlands in Bangladesh. Wetland bird diversity in Bangladesh is limited (Naher *et al*., 2021). The bird diversity of many such wetlands remains undocumented. Bird species composition, abundance and species diversity will provide baseline information to understand the ecological health of this habitat and to prepare conservation and management strategies of this unprotected wetland in future since this part is an integral part of the Arial Beel to maintain hydrological cycle and flood protection. The present study is the first attempt to prepare the checklist of birds along with species diversity, richness, local and global status.

Materials and Methods

Study area

The total area of the beel is about 14,436 ha (Islam, 2010). It lies approximately between 23^{o}32′N to 23^{o}48′N latitudes and 90^{o}08′E to 90^{o}27′E longitudes. The Arial beel belongs to Dhaka and Munshigonj districts and located at four upazillas namely Dohar (4%), Nawabgonj (24%), Sreenagar (67%) and Sirajdhikhan (5%) of which Dohar and Nawabgonj are in Dhaka district and Sreenagar and Sirajdhikhan are in Munshigonj district (Siddique, 2011). The Arial beel area is under the 15 demarked unions (Siddique, 2011), and Shologhar (N 23^{o}34′24.91″ E 90^{o}17′08.39″) is one of these (Figure 1). There are several small ponds (locally known as 'Denga') and

depressions with various sizes, shapes and depths in the beel which are the reservoirs of water and fishes in winter, farmers cultivated agricultural crops in the lowland collecting water from those ponds and depressions. The whole beel area, including these lowlands, was flooded by monsoon water while local people communicated themselves by boat. Floating cultivation over water is familiar in this area. The area is enriched with grasses and bushes [Water spinach (*Ipomoea aquatic*), Pink morning glory (*Ipomoea carnea*), Water hyacinth (*Eichhornia crassipes*), White water lily (*Nymphaea pubescens*), Creeping water primrose (*Ludwigia adscendens*), Water snowflake (*Nymphoidesindica*), Crested floating-heart (*Nymphoidescristatus*), Alligator weed (*Alternanthera philoxeroides*), Giant cane (*Arundo donax*), Vetiver grass (*Chrysopogon zizanioides*), Water lettuce (*Pistia stratiotes*), Four-leaved clover (*Marsilea minuta*), Minute duckweed (*Lemna perpusilla*), Asiatic pennywort (*Centella asiatica*), Bermuda grass (*Cynodon dactylon*)], large trees like Koroi (*Albizia procera*), Banyan (*Ficus bengalensis*), Indian Oak (*Barringtonia acutangular*) and some homestead trees like, Mango (*Mangifera indica*), Jackfruit (*Artocarpus heterophyllus*), Banana (*Musa* spp.), bamboo clumps etc.

Data Collection

Survey was conducted from March 2016 to February 2017 using three methods: transect line survey, point count and direct observation (Soka *et al*., 2013). Line Transect method proved most efficient in terms of data collection per unit effort (Yallop *et al*., 2003; Soka *et al*., 2013). The area was surveyed every after two weeks usually from morning (06:00h to 10:00h) and afternoon (15:00h to 1800/1900h or till dusk, depending on light), as the birds are most active during these time periods (Naher *et al*., 2021; Mukhopadhay and Shuvendu, 2017; Soka *et al*., 2013). The time schedule fluctuated depending on the seasonal variation. Total transect length was 12.87 km (12870m) ranged from 0.57 km to 4.78 km (2.16 ± 1.7, n=6) (Table 1). Each transect was repeated twice in a day. In this method, the observer slowly walks on a straight line and observed the birds from both sides. During population count 'point count' method was followed while the observer fixed a point at every 200m from the starting till ending. The fixed-radius point count method was used to record the species richness of avifauna at each count station (Bibby *et al*., 2000; Sutherland, 2006). We recorded bird species (seen or heard) within a 25 m radius of each of these points count stations in a 360° arc for 5 minutes. For each transect, an observer recorded any bird species and numbers in the area with the aid of binoculars. A total of 72 observation points were established with an interval of 200m apart. For water birds, observation sites were established at the edge of the beel at an interval of 200 meter from one site to another. In addition, opportunistic observations of birds at other times and in other places were included in order to produce a comprehensive checklist of the avifauna of the study area (Mukhopadhay and Shuvendu, 2017)

Birds were identified using standard field guides as Grimmett *et al.* (2011) and Halder (2010). Etrex-10 and Etrex-30 GPS meter were used to track the transect line and location of ponds. Binocular (Bushnell, 10x magnification) was used to detect the flock but specific individual identification was done by telescope (Braska and Gommu 40x magnification) precisely. Birds from 300 meter can easily be detectable through these telescopes. The year was subdivided into three seasons, such as November to February as winter, March to June as summer and July to October as rainy season (Naher *et al*., 2021; Khan and Ahsan, 2011). The local status of each

species was assessed based on the percentage of occurrence during observations (Khan, 1982; Naher *et al*., 2021; Khan and Ahsan, 2011): Very Common (VC) – a species was seen during 76% to 100% of the visits; Common (C) – a species was seen during 51% to 75% of the visits; Fairly

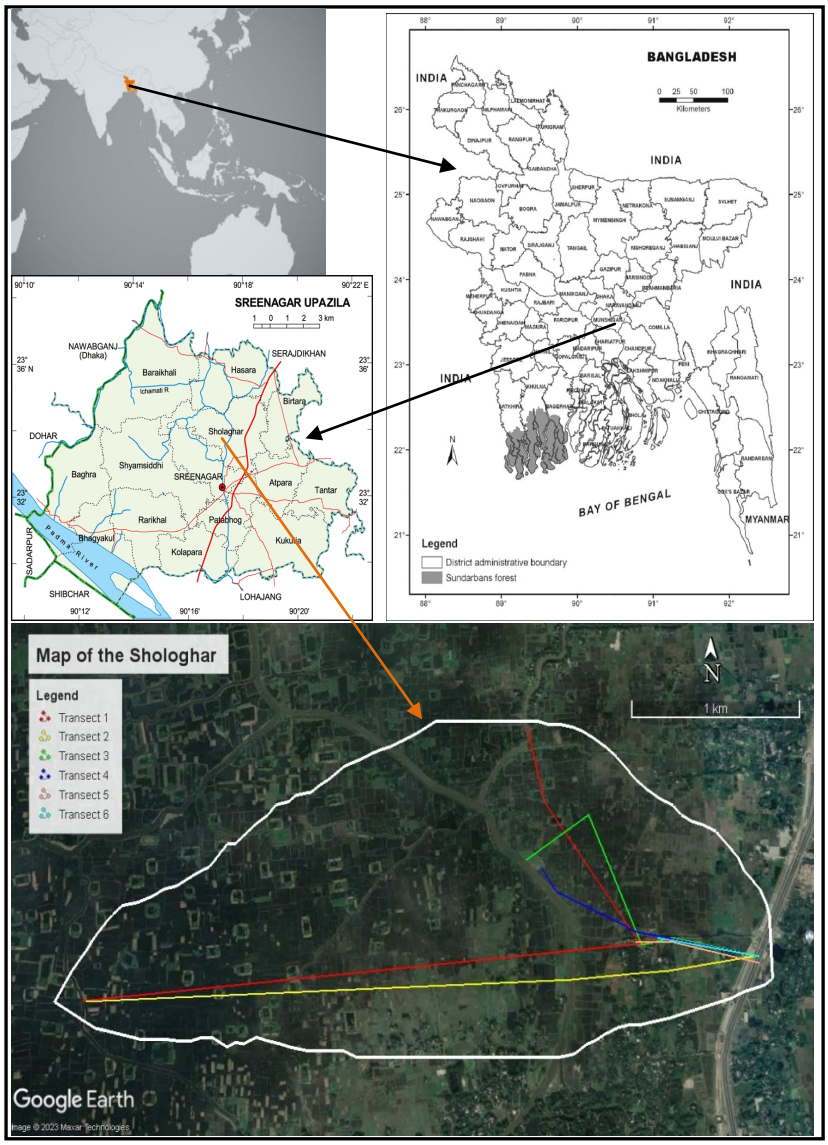

Fig.1. Map of the study area showing the transect lines.

Common (FC) – a species was seen during 26% to 50% of the visits; and Rare (R) – a species was seen single or in small number of occasions, i.e., up to 25% of the visits. The habitat was divided in two sites, terrestrial and aquatic. Monthly and seasonal variations of different birds were recorded. The conservation status of birds was taken from the IUCN Red List (2015). Feeding guild is defined as a group of species with similar foraging habits (Hutto, 1985). The observed

avian species were classified into five guilds, i.e., carnivore, omnivore, frugivore, nectarivore, granivore and insectivore following (Ali and Ripley, 1987).

Data analysis

Relative Abundance (%): The relative abundance of bird species was estimated following several previous studies (Amir *et al*., 2015; Bibby *et al*., 2000; Soka *et al*., 2013):

Relative abundance (RA) = n/N x 100

Where: n = The number of a particular detected bird species, N = The total number detected for overall species.

Table 1. Transect no and length using in the field during data collection

Transect no	Transect length (km)	Observation points (no)	Total length (km)	Average±SD(km)
1	0.57	4	12.87	2.1±1.7
2	0.70	5		
3	1.29	8		
4	1.78	10		
5	3.75	20		
6	4.78	25		

Relative diversity (RDi) of families: RDi was calculated using the following formula (Torre-Cuadros*et al*., 2007): RDi=Number of bird species in the family/Total number of species x 100.

Bird Diversity Indices: Bird diversity was calculated using Shannon-Weiner index and species richness was estimated using Simpson's and Margalef indices (Zakariaand Rajpar, 2013; Soka *et al*., 2013; Yashmita-Ulman and Singh, 2022). Jaccards's analysis was done to find out the equitability and individual rarefaction was performed to analyze the species richness according to months. Non-parametric Kruskal-Wallis tests was carried out separately to test the seasonal differences between species richness and different foraging guilds since the data was not normally distributed (Mukhopadhay and Shuvendu, 2017). We used PAST (Paleontological statistics software package for education and data analysis) statistical software (3.2 version) to perform all these analyses (Obateru *et al*., 2019).

Results and Discussion

Species diversity of birds

A total of 16,743 individuals of birds belonging to 75 species, 63 genera, 35 families and 14 orders (Table 2) were recorded in the entire year. Nine orders (64.3%) comprised of only one family and fifteen families contributed single genus and single species each (Table 2, Fig. 2). Diversity analyses revealed the highly diversified avifauna in this area (H=3.087).The landscape of the area comprised of heterogenic habitat like wetlands, ponds, ditches, bushy area, grassland and agricultural lands which sheltered diversified species. High diverse and biologically rich habitats in wetlands provided suitable habitat to many groups of wild animals (Yashmita-Ulmanand Singh, 2022).

Non-passerine and passerine birds

Non-passerine birds contributed more species diversity (40 species, 53%) but less population (19% of total population) than passerine birds (Table 3). Higher non-passerine birds were also seen in other wetland in Dhaka (Naher *et al.*, 2021).

Migratory and resident birds

Migratory species (13 spp. 17%) were almost one-fifth of the resident birds (62 spp. 83%) in the study area which contributed 16% of total population (Table 3). Resident birds were dominant both in passerine (27 spp., 36%) and non-passerine species (35 spp., 47%) compare to migratory species (Table 3). Resident passerine birds contributed 66% of total population and resident-passerines were 18% of total population. Among non-passerine migratory birds, Common snipe (*Gallinago gallinago*) was dominant and of passerine migratory birds, Yellow Wagtail (*Motacilla flava)* was dominant in the present study. The abundance of these migratory birds indicated the presence of suitable habitats in this wetland. Among non-passerine resident birds, House Swift (*Apus nipalensis)* was dominant and in passerine resident birds, Baya weaver (*Ploceus philippinus)* was dominant (Table 2). Agricultural fields, shrubs and grasslands in the study area attracted these birds. Wetlands are important habitat to many resident and migratory birds due to provide feeding, nesting and stopover sites (Kumar *et al*., 2016).

Terrestrial and wetland birds

Wetland bird species were almost half of the terrestrial species (Table 3) but the population of wetland birds was almost one-third of the terrestrial birds (Table 3). Agricultural fields, trees, shrubs, bushes and grassland in the study area provided feeding resources and breeding sites to terrestrial birds. Strong association was revealed with the presence of trees, shrubs, emergent vegetation, ground vegetation cover and grasses (Rajpar and Zakaria, 2011). Emergent vegetation in wetlands provided insects, amphibians, invertebrates and small fishes to aquatic birds (Rajpar and Zakaria, 2011). Wetlands bird preferred intermediate plant cover for resting and sleeping instead of open fields and tall tree cover (Comin *et al*., 2001).

Almost sixty percent of the total species and seventy percent of total population of terrestrial birds were resident which indicated the area supported food resources to them in the entire year. Only 9% of total species and 4% of total population of terrestrial birds were migratory (Table 3) suggested that this area supported lower facilities for migratory species during winter. Among wetland birds, most of the species (24%) and population (12%) were resident compare to migratory (8% and 12 % respectively) (Table 3). The aquatic habitat such as, ponds, ditches and canals were a source of different food items throughout the year which attracted more resident birds.

Country status and global status of recorded birds

According to IUCN Red List in Bangladesh (2015), all of the recorded species were least concern (Table 2 and 3) except only one near threatened (NT) species like Yellow Wattled Lapwing *(Vanellus malabaricus*). Globally, all recorded species were least concern (IUCN Bangladesh 2015).

Table 2. Percentage of relative abundance of recorded birds at Shologhar in Arial Beel

Scientific Name	English Name	Bangla Name	CS	GS	M/R	FG	Habitat	Recorded Individuals	RA (%)
O- Columbiformes									
F-Columbidae									
Columba livia	Rock Dove	Jalali Kobutor	LC	LC	R	G	T	324	1.94
Streptopelia decaocto	Eurasian Collared Dove	Raj Ghughu	LC	LC	R	G	T	70	0.42
Spilopelia chinensis	Eastern Spotted Dove	Tila Ghughu	LC	LC	R	G	T	178	1.06
O- Caprimulgiformes									
F-Apodidae									
Cypsiurus balasiensis	Asian Palm Swift	Asio Talbatasi	LC	LC	R	I	W	334	1.99
Apus nipalensis (A. affinis)	House Swift	Ghorbatashi	LC	LC	R	I	W	400	2.39
O- Cuculiformes									
F-Cuculidae									
Centropus sinensis	Greater Coucal	Boro Kanakua	LC	LC	R	O	T	57	0.34
Centropus bengalensis	Lesser Coucal	Choto Kanakua	LC	LC	R	O	T	29	0.17
Eudynamys scolopaceus	Western Koel	Kala Kokil	LC	LC	R	O	T	16	0.10
Cacomantis merulinus	Plaintive Cuckoo	Koroon Papia	LC	LC	R	I	T	1	0.01
O- Gruiformes									
F-Rallidae									
Amaurornis phoenicurus	White-breasted Water Hen	Dahuk	LC	LC	M	O	W	22	0.13
Gallinula chloropus	Common Moorhen	Jol Morog	LC	LC	R	O	W	6	0.04
O- Ciconiformes									
F-Ciconidae									
Anastomus oscitans	Asian Openbill	Shamukhkhol	LC	LC	R	O	W	1	0.01

Scientific Name	English Name	Bangla Name	CS	GS	M/R	FG	Habitat	Recorded Individuals	RA (%)
O- Peleceniformes									
F-Ardeidae									
Ixobrychus sinensis	Yellow Bittern	Holdey Bok	LC	LC	R	C	W	1	0.01
Nycticorax nycticorax	Black crowned Night Heron	Nishi Bok	LC	LC	R	C	W	20	0.12
Ardeola grayii	Indian Pond Heron	Kani Bok	LC	LC	R	C	W	181	1.08
Bubulcus ibis	Cattle Egret	Go-Bok	LC	LC	R	C	W	142	0.85
Ardea (Egretta) intermedia	Intermediate Egret	Majhari Bok	LC	LC	R	C	W	21	0.13
Egretta garzetta	Little Egret	Chhoto Boga	LC	LC	R	C	W	144	0.86
O- Suliformes									
F-Phalacrocoracidae									
Microcarbo (*Phalacrocorax*) *niger*	Little Cormorant	Chhoto Pankouri	LC	LC	R	C	W	309	1.85
O- Charadriformes									
F-Chardridae									
Vanellus malabaricus	Yellow-wattled Lapwing	Holdegal Titi	NT	LC	R	I	W	20	0.12
Vanellus indicus	Red-wattled Lapwing	Hot titi	LC	LC	R	I	W	10	0.06
F-Jacanidae									
Metopidius indicus	Bronze-winged Jacana	Jol Pipi	LC	LC	R	C	W	55	0.33
F-Scolopacidae									
Gallinago gallinago	Common Snipe	Kadakhocha	LC	LC	M	C	W	39	0.23
Actitis hypoleucos	Common Sandpiper	Pati Batan	LC	LC	M	C	W	15	0.09
Tringa glareola	Wood Sandpiper	Bon Batan	LC	LC	M	C	W	10	0.06
O-Accipitriformes									
F-Accipitridae									
Elanus caeruleus	Black winged Kite	Katua Chill	LC	LC	R	C	T	52	0.31
Milvus migrans	Black kite	Bhubon Chil	LC	LC	R	C	T	145	0.87
Haliasturindus	Braminy Kite	Shankhachil	LC	LC	R	C	W	114	0.68

Scientific Name	English Name	Bangla Name	CS	GS	M/R	FG	Habitat	Recorded Individuals	RA (%)
O- Bucerotiformes									
F- Upupidae									
Upupa epops	Common Hoopoe	Hoodhood	LC	LC	R	I	T	33	0.20
O-Coraciformes									
F- Meropidae									
Merops orientalis	Asian Green Bee- eater	Sobuj Suichor	LC	LC	R	I	T	99	0.59
F-Alcedinidae									
Alcedo atthis	Common Kingfisher	Choto Masranga	LC	LC	R	C	W	46	0.27
Ceryle rudis	Pied Kingfisher	Pakra Maachranga	LC	LC	R	C	W	42	0.25
Halcyon smyrnensis	White-breasted Kingfisher	Dholagola Maachranga	LC	LC	R	C	W	94	0.56
O-Piciformes									
F- Megalaimidae									
Psilopogon asiaticus	Blue-throated Barbet	Neelgola Bosontobauri	LC	LC	R	F	T	31	0.19
F-Picidae									
Dinopium benghalense	Black-rumped Flameback	Bangla Kaththokra	LC	LC	R	I	T	21	0.13
Micropternus(*Celeus*) *brachyurus*	Rufous Woodpecker	Khoira Kathkurali	LC	LC	R	I	T	14	0.08
Picus xanthopygaeus	Streak-throated Woodpecker	Dagigola Kathkurali	LC	LC	R	I	T	9	0.05
Dendrocopos macei	Fulvous breasted Woodpecker	Batabi Kathkurali	LC	LC	R	I	T	14	0.08
O-Falconiformes									
F- Falconidae									
Falco tinnunculus	Common Kestrel	Kestrel	LC	LC	M	C	T	1	0.01
O-Psittaciformes									
F-Psittacidae									
Psittacula krameri	Rose-ringed Parakeet	Shabuj Tia	LC	LC	R	F	T	18	0.11

Scientific Name	English Name	Bangla Name	CS	GS	M/R	FG	Habitat	Recorded Individuals	RA (%)
O- Passeriformes									
F- Aegithinidae									
Aegithina tiphia	Common Iora	Fatikjal	LC	LC	R	I	T	117	0.70
F-Campephagidae									
Pericrocotus cinnamomeus	Small Minivet	Choto Saheli	LC	LC	R	I	T	99	0.59
F- Lanidae									
Lanius cristatus	Brown Shrike	Badami Latora	LC	LC	M	I	T	72	0.43
Lanius schach	Long Tailed Shrike	Lenja Latora	LC	LC	R	I	T	158	0.94
F-Oriolidae									
Oriolus xanthornus	Black Hooded Oriole	Holdey Pakhi	LC	LC	R	O	T	53	0.32
F-Dicruridiae									
Dicrurus macrocercus	Black Drongo	Kalo Fingey	LC	LC	R	I	T	557	3.33
Dicrurus leucophaeus	Ashy Drongo	Metey Fingey	LC	LC	M	I	T	31	0.19
F-Corvidae									
Dendrocitta vagabunda	Rufous Treepie	Hari Chacha	LC	LC	R	O	T	17	0.10
Corvus splendens	House Crow	Pati Kak	LC	LC	R	O	T	816	4.87
Corvus levaillantii	Jungle Crow	Dar Kak	LC	LC	R	O	T	120	0.72
F-Herundinidae									
Hirundo rustica	Barn Swallow	Pati Ababil	LC	LC	M	I	T	498	2.97
F-Cisticolidae									
Cisticola juncidis	Zitting Cisticola	Bhomra Soton	LC	LC	R	I	T	114	0.68
Prinia inornata	Plain Prinia	Nirol Prinia	LC	LC	R	I	T	8	0.05
F-Pycnonotidae									
Pycnonotus cafer	Red-vented Bulbul	Bangla Bulbuli	LC	LC	R	O	T	363	2.17
F- Sylvidae									
Orthotomus sutorius	Common Tailor Bird	Pati Tuntuni	LC	LC	R	I	T	71	0.42
Megalurus palustris	Striated Grassbird	Dagi Ghaspakhi	LC	LC	R	I	T	170	1.02
Phylloscopus fuscatus	Dusky Warbler	Kalchey Futki	LC	LC	M	I	T	37	0.22

Scientific Name	English Name	Bangla Name	CS	GS	M/R	FG	Habitat	Recorded Individuals	RA (%)
F-Timalidae									
Turdoides striata	Jungle Babbler	Bon Satarey	LC	LC	R	I	T	2	0.01
F-Sturnidae									
Sturnus contra	Asian Pied Starling	Gobrey Shalik	LC	LC	R	O	T	972	5.81
Sturnus malabaricus	Chestnut-tailed Starling	Kath Salik	LC	LC	R	O	T	14	0.08
Sturnus pagodarum	Brahminy Starling	Harbola, Baman Shalik	LC	LC	R	O	T	24	0.14
Acridotheres fuscus	Jungle Myna	Jhuti Shalik	LC	LC	R	O	T	145	0.87
Acridotheres ginginianus	Bank Myna	Gaang Shalik	LC	LC	R	O	T	129	0.77
Acridotheres tristis	Common Myna	Bhat Shalik	LC	LC	R	O	T	985	5.88
F-Muscicapidae									
Ficedula albicilla	Taiga Flycatcher	Lalbok Chotok	LC	LC	M	I	T	11	0.07
Ficedula westermanni	Little Pied Flycatcher	Choto Pakrachutki	LC	LC	M	I	T	3	0.02
Copsychus saularis	Oriental Magpie Robin	Doel	LC	LC	R	I	T	116	0.69
F-Nectarinidae									
Nectarinia zeylonica	Purple-rumped Sunbird	Beguni Komor Moutushi	LC	LC	R	N	T	7	0.04
Nectarinia asiatica	Purple Sunbird	Beguni Moutushi	LC	LC	R	N	T	20	0.12
F-Passeridae									
Passer domesticus	House Sparrow	Pati Chorui	LC	LC	R	O	T	1220	7.29
F-Ploceidae									
Ploceus philippinus	Baya Weaver	Deshi Babui	LC	LC	R	G	T	4370	26.10
F-Estrilidae									
Lonchura punctulata	Scaly-breasted Munia	Tila Munia	LC	LC	R	G	T	400	2.39
F-Motacilidae									
Motacilla citreola	Citrine Wagtail	Holdey Matha Khonjon	LC	LC	M	I	W	680	4.06
Motacilla flava	Yellow Wagtail	Holdey Khonjon	LC	LC	M	I	W	1200	7.17
Anthus rufulus	Paddy Field Pipit	Dhani Tulika	LC	LC	R	I	T	6	0.04

Note:CS=Country Status, GS=Global Status, M=Migratory,R=Resident, LC=Least Concern, NT=Near Threatened, FG=Feeding guilds, G=Granivorous, I=Insectivorous, O=Omnivorous, C=Carnivorous, F=Frugivorous, N=Nectarivorous, RA=Relative abundance, T=Terrestrial, W=Wetland

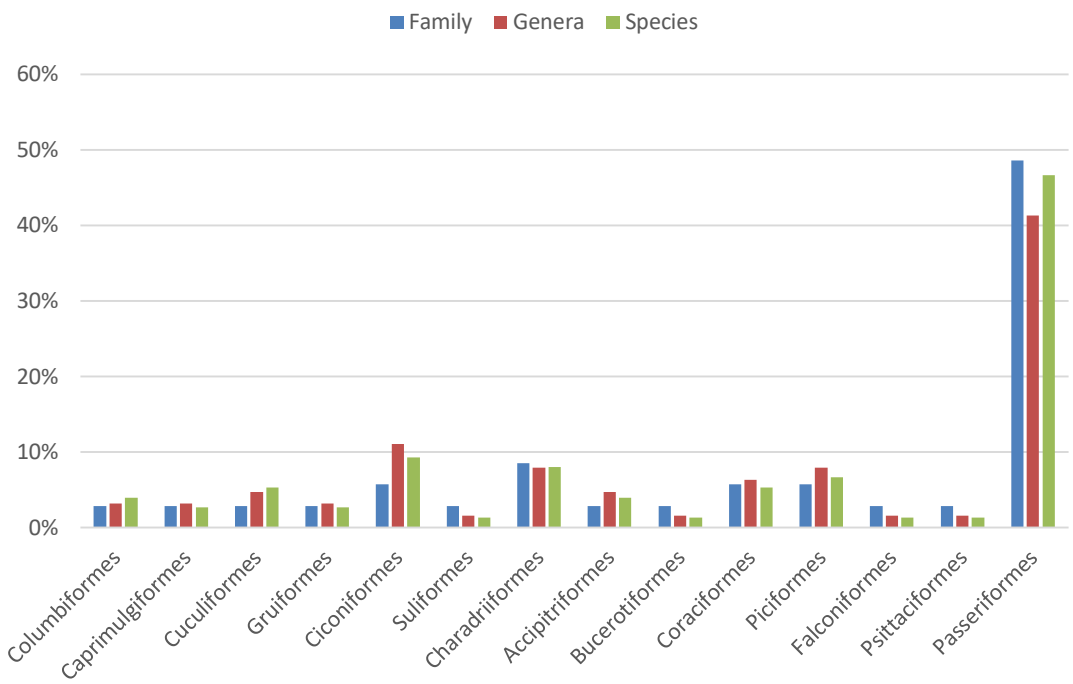

Fig. 2. Orders of recorded birds with percentages of families, genera and species.

Table 3. Percentages of species diversity and population of birds according to different categories

Categories	Species diversity	% of total species	Population	% of total population
Wetland	24	32	12837	77
Terrestrial	51	68	3906	23
Passerine	35	47	13605	81
Non passerine	40	53	3138	19
Migratory	13	17	2619	16
Resident	62	83	14124	84
Threatened	1	1.3	20	1.2
Least concern	74	98.7	16723	98.8
Resident passerines	27	36	11073	66
Resident non-passerines	35	47	3051	18
Migratory passerines	8	11	2532	15
Migratory non-passerines	5	7	87	1

Categories	Species diversity	% of total species	Population	% of total population
Wetland resident	18	24	1940	12
Wetland migratory	6	8	1966	12
Terrestrial resident	44	59	12184	73
Terrestrial migratory	7	9	653	4

Relative abundance of birds according to species, families and orders

Among 35 families, only 12 families supported 60 percent species diversity in the study area and the remaining 13 families contributed the rest forty percent (Table 2). Relative diversity analysis revealed that Ardeidae and Sturnidae were the highest diversified families in the study area (6 species in each, RDi = 8), followed by Cuculidae, Picidae and Sylvidae (4 species each, RDi = 5.3), while 16 families were represented single species from each (RDi = 1.3) (Table 4). Emergent vegetation with shallow water was a habitat of small fishes, invertebrates, amphibians, and insect which influenced the presence of several species like egrets, bitterns, herons etc. The Ardeidae showed the highest diversity of species in other earlier studies in wetland habitats (Mukhopadhyay and Mazumdar, 2017;Vijayan *et al*., 2006; Kumar, 2006; Surana, 2007; Zakaria *et al*., 2009; Zakaria and Rajpar, 2010; Rajpar and Zakaria, 2011; Dal and Vaghela, 2015,).

Table 4. Relative diversity (RDi) of various avian families in Shologhar

Families	No of species	RDi
Ardeidae, Sturnidae	6	8
Cuculidae, Picidae	4	5.3
Columbidae, Scolopacidae, Accipitridae, Alcedinidae, Corvidae, Muscicapidae, Motacilidae, Sylvidae	3	4
Apodidea, Rallidae, Chardridae, Lanidae, Dicruridiae, Cisticolidae, Nectarinidae	2	2.7
Ciconidae, Phalacrocoracidae, Jacanidae, Upupidae, Meropidae, Megalaimidae, Falconidae, Psittacidae, Aegithinidae, Campephagidae, Oriolidae, Herundinidae, Pycnonotidae, Timalidae, Passeridae, Ploceidae, Estrilidae,	1	1.3

Among 75 species, the population of 32 species influenced more in richness of birds in the study area and the remaining 43 species contributed less (Table 2). Baya Weaver contributed the highest (26%) followed by House Sparrow (7%) and Yellow wagtail (7%). According to family, it was Ploceidae (26%) followed by Sturnidae (14%) and Motacilidae (11%) (Fig. 3). According to order, Passeriformes (n=13605, 81.3%) ranked the highest in terms of population followed by Caprimulgiformes (n=734) and Columbiformes (n=570,) (Fig. 4) but Passeriformes occupied the highest rank in terms of species (25spp., 33.33%) followed by Ciconiformes (7spp., 9.3%) and Charadriformes (6spp, 8%) (Fig. 5).

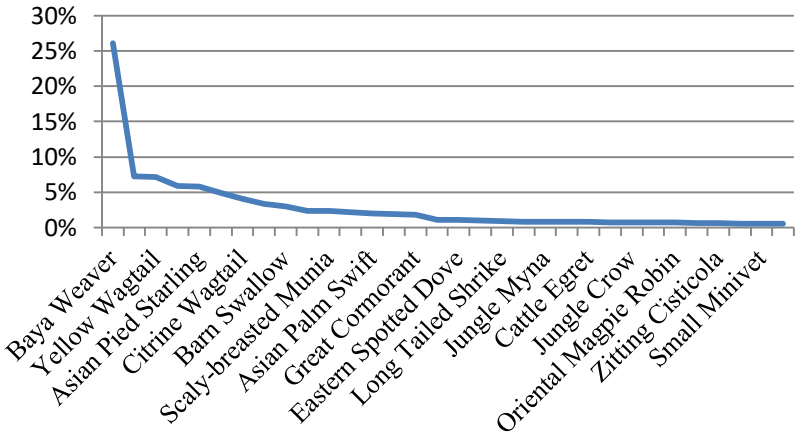

Fig. 3. Relative percentage of contribution in richness of different species in the study area.

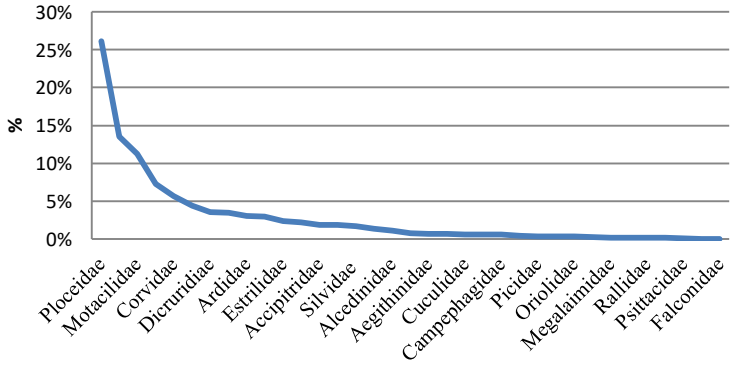

Fig.4. Relative percentage of contribution in richness of different families in the study area.

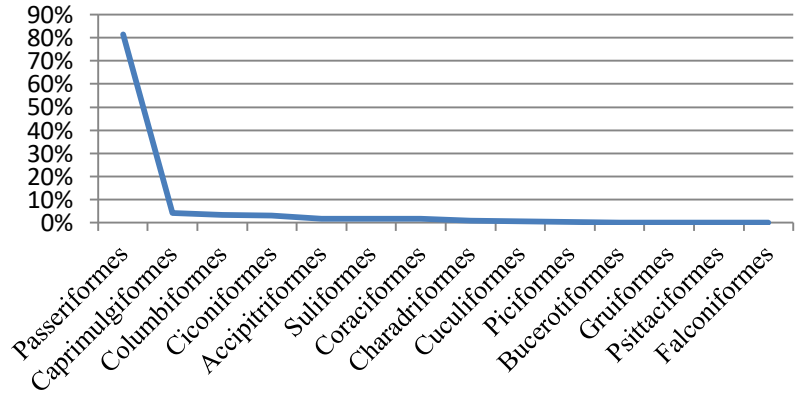

Fig. 5. Relative percentage of contribution in richness of different orders in the study area.

Local status of birds in the study area

Most of the species were very common (40 spp.) followed by common, fairly common and rare (Fig.6). Yellow wagtail was highly abundant whereas Pailntive Cuckoo (*Cacomantis merulinus*), Asian Openbill (*Anastomus oscitans*), Common Kestrel (*Falco tinnunculus*) and Yellow Bittern (*Ixobrychus sinensis*) were the least abundant species and recorded only one individual each and only once in the entire year (Table 5). Two individuals of Jungle Babbler were recorded once in the entire year which was considered another least abundant species (Table 5).

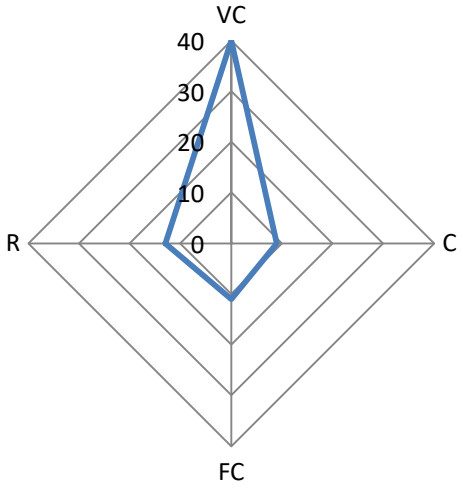

Fig. 6. Local status of birds in the study area.

Monthly and seasonal variation of birds

The species diversity (69spp.) and individual number of birds (12% of the total population) were the highest in March due to abundance of both migratory and resident species. The lowest diversity and population were in May (33 spp., 4% of the total recorded population) and June (41 spp., 4%) (Table 5, Fig. 7) because of seasonal dispersal. Most of the species started nesting and breeding during these months and might be moved elsewhere. From the individual rarefaction it is shown that the highest species richness was March and lowest in May and June (Fig 8). Shannon-Wiener index (H′) revealed the highest diversity was in September and October while many species started to come to the study area for foraging including migratory species but Simpson's richness index (D) showed the richness was in February, August, September and October. Margalef index shows that the species was rich in March and the highest evenness (Evenness_e^H/S) was in September (Table 6). Both the resident and migratory bird diversity was the highest in March (58spp. and 11 spp. respectively) (Fig.9). But the population of migratory birds were the highest in March (33% of total migratory bird population) and resident birds were the highest in August (12% of total resident bird population). Seven species were seen only once in the entire year (Table 5). From Equitability _J analysis it is found that the recorded bird species was the highest similar (78%) in September (Table 6). Seasonal dispersal of birds influenced the richness and evenness in the study area.

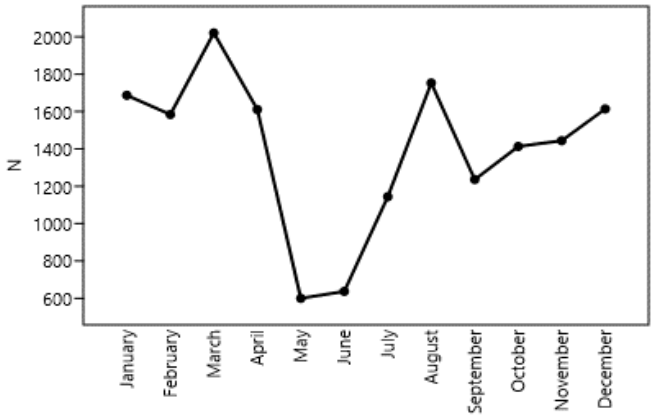

Fig. 7. Population of birds according to months.

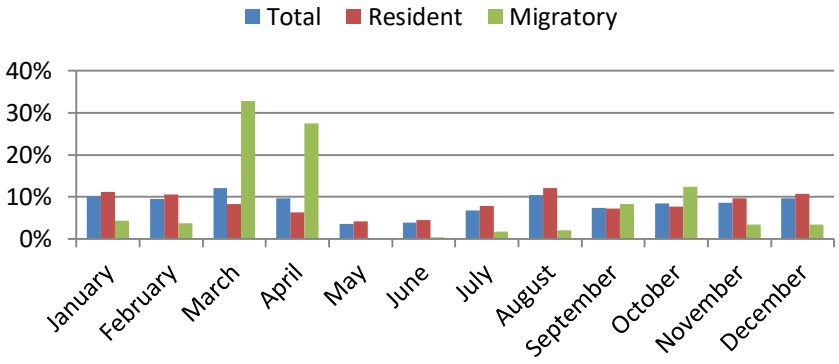

Fig. 8. Monthly variation (%) of bird diversify in the study area.

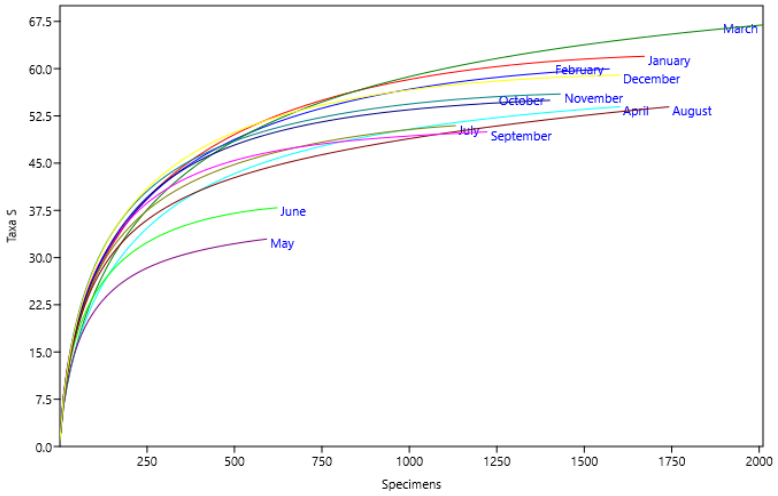

Fig. 9. Individual rarefaction according to months of the year.

Overall, the total bird population was highly recorded in winter season (Fig. 10). The migratory birds were the highest in summer due to abundance of summer visitors and the resident birds were the highest in monsoon season while the area was inundated with rainy water and provided breeding, nesting and feeding opportunities to many resident birds. No significant seasonal variation was noticed in species richness of migratory species (Kruskal-Wallis test: $K = 0.05$, $df = 2$, $p = 0.971$) and resident species (Kruskal-Wallis test: $K = 1.9$, $df = 2$, $p = 0.379$).

Species composition and population according to feeding guilds of birds in Shologhar

According to feeding guilds and in terms of species diversity, insectivore species were predominant (30 spp., 40% of the total diversity) followed by carnivores (18 spp., 24% of the total diversity), omnivores (18 spp., 24% of the total diversity) and granivores species (5 spp., 7% of the total diversity) (Table 7). But according to population, it was granivores (32% of the total population) followed by omnivores (30% of the total population) and insectivore birds (29.5% of the total population) (Table 7). No significant seasonal variation occurred among the species richness of different feeding guilds (Kruskal-Wallis test: $K = 0.86$, $df = 5$, $p = 0.65$). The food resources availability shaped the diversity of birds as evident in other study (Tanalgo *et al.,* 2015). Rice fields in the study area played an important role for foraging and breeding habitat to many birds as seen in other study (Tourenq *et al.,* 2015). During pre-and post harvest season and field preparation the rice fields were suitable for feeding and nesting grounds of many granivores and insectivores which is similar to the findings of Tourenq *et al.,* (2001). Prey availability increases during post-harvest season and field preparation (Tanalgo *et al.,* 2015). The diversified insectivore birds play a crucial role in bio-control of various insect pests thriving in agriculture, horticulture and forests (Mahabal, 2005; Thakur *et al*., 2010) in the adjoining areas. Abundant insectivore birds in and around the agro-forests were evident by Blake and Loiselle (2001), Rajashekara and Venkatesha (2014). Aquatic bodies, such as ponds, canals, ditches and agricultural fields provided fishes, invertebrates, reptiles such as lizards and snakes, amphibians, mammals like rats, mice etc. which influenced the presence of carnivores in this area. Similar findings were reported by Stafford *et al*., (2010) and King *et al*., (2010). Sowing stage was vital to carnivorous birds but post-harvest flooded fields were valuable for granivorous species (Acosta *et al.,* 2010). Least abundant nectarivores and frugivores indicated the limited abundance of fruiting trees and flowering trees in the study area. Nectar availability influenced the abundance and diversity of Nectarivores (Tanalgo *et al*., 2015).

Table 5. Recorded birds in the study area according to different months of the year

English Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Rock Dove	48	51	20	20	12	16	22	-	20	30	40	45	324
Eurasian Collared Dove	8	7	4	4	-	-	-	9	7	8	11	12	70
Eastern Spotted Dove	32	29	10	8	7	5	11	18	10	10	17	21	178
Asian Palm Swift	40	44	20	23	10	15	23	42	21	21	33	42	334
House Swift	37	42	30	40	35	32	30	31	28	20	34	41	400
Greater Coucal	8	7	6	4	3	2	4	6	3	3	6	5	57
Lesser Coucal	3	2	2	4	2	1	2	1	3	2	3	4	29
Western Koel	2	2	1	1	-	2	-	1	-	2	3	2	16
Plaintive Cuckoo	-	-	-	-	-	-	-	1	-	-	-	-	1
White-breasted Water Hen	3	2	3	2	2	3	0	2	1	1	2	1	22
Common Moorhen	-	-	-	-	-	-	-	6	-	-	-	-	6
Asian Openbill	-	-	-	-	-	-	-	-	-	-	-	-	1
Yellow Bittern	-	-	-	-	-	-	-	1	-	-	-	-	1
Black crowned Night Heron	-	-	-	-	-	2	-	18	-	-	-	-	20
Indian Pond Heron	13	16	22	16	13	10	20	22	12	12	11	14	181
Cattle Egret	10	8	9	12	20	-	8	18	15	12	13	17	142
Intermediate Egret	2	2	2	1	-	1	1	2	3	2	3	2	21
Little Egret	12	13	10	14	10	15	8	13	12	16	11	10	144
Little Cormorant	40	42	30	30	10	8	25	30	18	18	27	31	309
Yellow Wattled Lapwing	2	4	4	-	-	-	2	-	-	2	2	4	20
Red Wattled Lapwing	1	1	2	-	-	-	2	-	-	-	2	2	10
Bronze-winged Jacana	3	4	8	-	-	-	8	20	4	4	2	2	55
Common Snipe	4	6	6	5	-	-	-	-	-	5	7	6	39
Common Sandpiper	3	2	4	2	-	-	-	-	-	-	-	4	15
Wood Sandpiper	3	3	2	0	-	-	-	-	-	-	-	2	10
Black winged Kite	2	4	2	5	6	4	2	8	4	4	5	6	52
Black kite	10	9	12	16	5	4	12	30	12	10	15	10	145
Braminy Kite	6	8	8	7	4	2	8	36	9	9	7	10	114
Common Hooopoe	4	4	2	2	-	-	2	2	-	4	6	7	33
Asian Green Bee- eater	13	11	10	13	-	-	-	14	15	10	7	6	99

English Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Common Kingfisher	5	5	4	5	1	2	6	-	4	4	4	6	46
Pied Kingfisher	4	2	1	2	1	3	3	5	6	4	5	6	42
White throated Kingfisher	6	3	9	12	6	4	11	9	8	8	10	8	94
Blue-throated Barbet	4	2	1	2	1	3	2	1	5	4	3	3	31
Black-rumpedFlameback	2	4	1	2	2	-	2	1	1	3	1	2	21
Rufous Woodpecker	1	1	2	1	2	-	1	1	2	-	2	1	14
Common Kestrel	-	-	1	-	-	1	-	-	-	-	-	-	1
Streak-throated Woodpecker	2	2	1	1	-	-	1	2	-	-	-	-	9
Fulvous breasted Woodpecker	2	2	3	1	-	-	2	-	-	-	2	2	14
Rose-ringed Parakeet	4	6	4	-	-	-	-	-	-	2	-	2	18
Common Iora	10	10	15	9	-	-	12	8	7	10	18	18	117
Small Minivet	8	6	9	7	-	8	10	12	10	9	10	10	99
Brown Shrike	10	8	5	3	-	6	7	8	6	8	4	7	72
Long Tailed Shrike	17	18	12	14	6	5	9	24	7	7	21	18	158
Black Hooded Oriole	3	4	4	5	3	4	5	4	5	5	5	6	53
Black Drongo	65	63	40	58	24	32	42	50	40	40	54	49	557
Ashy Drongo	8	-	-	-	-	-	-	-	4	6	8	5	31
Rufous Treepie	2	2	1	1	-	-	1	-	3	2	2	3	17
House Crow	120	123	50	60	20	25	44	60	70	70	89	85	816
Jungle Crow	14	16	35	-	-	-	-	16	-	-	19	20	120
Barn Swallow	76	70	35	-	-	-	35	40	60	60	62	60	498
ZittingCisticola	13	17	6	4	4	8	6	13	8	8	14	13	114
Plain Prinia	-	-	4	-	-	-	4	-	-	-	-	-	8
Red - vented Bulbul	32	35	30	8	14	23	30	40	30	30	43	48	363
Common Tailor Bird	6	11	4	6	-	-	4	4	4	4	13	15	71
Striated Grassbird	21	24	12	7	5	6	11	30	13	13	16	12	170
Dusky Warbler	2	4	4	6	-	-	2	2	3	4	6	4	37
Jungle Babbler	-	-	2	-	-	-	-	-	-	-	-	-	2
Asian Pied Starling	70	87	60	45	40	50	80	70	100	150	100	120	972
Chestnut-tailed Starling	-	-	4	-	-	-	4	6	-	-	-	-	14
Brahminy Starling	4	2	3	5	-	-	-	-	-	4	2	4	24

English Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Jungle Myna	16	12	14	12	-	10	9	8	11	14	18	21	145
Bank Myna	10	12	10	9	-	15	12	-	8	16	17	20	129
Common Myna	130	140	40	35	35	40	40	100	120	120	95	90	985
Taiga Flycatcher	1	1	1	-	-	-	2	1	1	1	1	2	11
Little Pied Flycatcher	2	-	-	-	-	-	-	1	-	-	-	-	3
Oriental Magpie Robin	13	15	7	8	6	8	7	4	11	11	11	15	116
Purple-rumped Sunbird	2	3	-	2	-	-	-	-	-	-	-	-	7
Purple Sunbird	3	1	1	2	1	2	-	2	2	1	2	3	20
House Sparrow	90	100	50	50	40	60	50	200	150	150	120	160	1220
Baya Weaver	600	450	500	300	250	200	300	500	200	200	400	470	4370
Scaly-breasted Munia	-	-	-	-	-	-	200	200	-	-	-	-	400
Citrine Wagtail	-	-	300	300	-	-	-	-	40	40	-	-	680
Yellow Wagtail	-	-	500	400	-	-	-	-	100	200	-	-	1200
Paddy Field Pipit	-	-	6	-	-	-	-	-	-	-	-	-	6

Note: Jan=January, Feb=February, Mar=March, Apr=April, Jun=June, Jul=July, Aug=August, Sep=September, Oct=October, Nov=November, Dec=December

Table 6. Diversity indices according to months of the year

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Taxa_S	62	60	67	54	33	38	51	54	50	55	56	59
Individuals	1687	1584	2021	1611	600	637	1144	1753	1236	1413	1444	1614
Simpson_1-D	0.85	0.9	0.85	0.86	0.80	0.87	0.88	0.9	0.9	0.9	0.89	0.8
Shannon_H	2.8	2.9	2.6	2.6	2.4	2.7	2.9	2.8	3.0	3.0	2.9	2.9
Evenness_e^H/S	0.26	0.31	0.20	0.25	0.34	0.39	0.3	0.31	0.42	0.38	0.3	0.3
Margalef	8.2	8.0	8.7	7.2	5.0	5.7	7.1	7.1	6.8	7.4	7.6	7.9
Equitability_J	0.67	0.72	0.62	0.66	0.69	0.7	0.7	0.71	0.78	0.76	0.74	0.73

Note: Jan=January, Feb=February, Mar=March, Apr=April, Jun=June, Jul=July, Aug=August, Sep=September, Oct=October, Nov=November, Dec=December

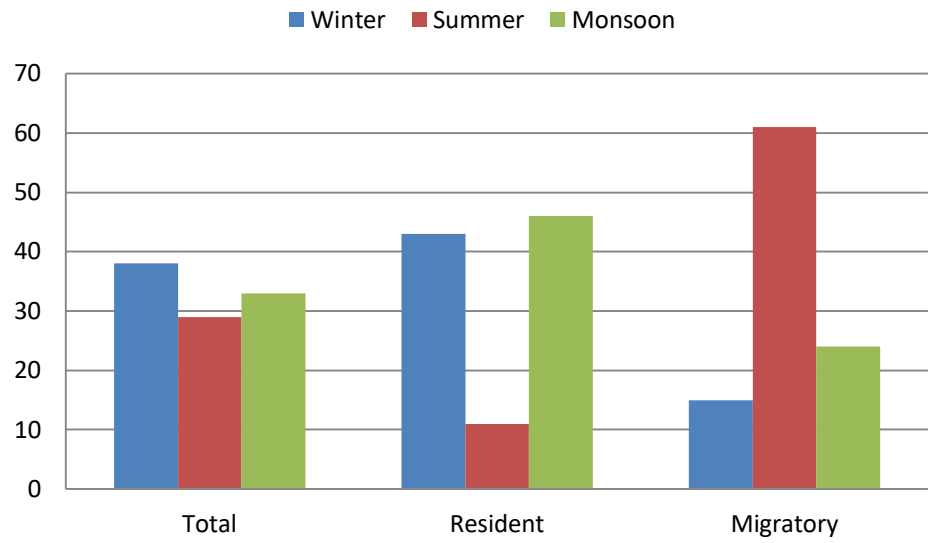

Fig. 10. Seasonal variation (%) of bird diversify in the study area.

Table 7. Species diversity and population of birds according to feeding guilds

Diet types	Spp. No	% of total species diversity	Population	% of total population
Granivore	5	7	5342	32
Insectivore	30	40	4904	29.5
Carnivore	18	24	1431	8
Omnivore	18	24	4990	30
Frugivore	2	3	49	0.3
Nectarivore	2	3	27	0.2
Total	75	100	16743	100

Conclusion

The study concluded that this study site is very important to the bird communities. There was greater variation in species composition between terrestrial and aquatic habitats. Terrestrial habitat contributed much in terms of species composition than aquatic habitat which reflects that the aquatic habitat in this area is degraded and converted into terrestrial one. Non-passeriformes species was more diverse but Passeriformes bird population was predominant. Ardeidae and Stunidae families were dominant. The highest diversity and population was found in March and lowest in May and June and in winter season. Granivorous birds were highly abundant. Encroachment of local people for fish culture, development works and seasonal agriculture threatens the aquatic habitat. Illegal hunting and trapping of birds, use of insecticides and pesticides by local people

added more threats. The farmers used different pesticides in the adjoining agricultural fields, indiscriminate use of which could have severe ecological consequences and adverse effect on the avifauna of this study area and by consuming these, the birds might be contaminated with pesticides. Severe ecological consequences may occur by consuming pesticide contaminated food resources like insects, seeds, fishes, invertebrates and other food items (Sánchez- Bayo *et al.*, 1999) resulting toxic effects and bioaccumulation of such chemicals (Sánchez-Bayo, 2011). The baseline study revealed the habitat quality of the degraded part of arial beel and local government should take initiative to conserve this area. Land use planning may enhance the bird diversity and richness in this landscape and regular monitoring and awareness creation among local people may improve the habitat quality.

Acknowledgement

This research was done by the Jagannath University research fund (2014-15), the authors are grateful to the selection committee who were selected this research for funding. The authors would like to express their heartiest gratitude to local people and Md. Sabbir Hasan and Md. Salauddin, ex-students, Department of Zoology, Jagannath University, Dhaka for their help during data collection.

References

Acosta, M., Mugica, L., Blanco, D., López-Lanús, B., Dias, R. A., Doodnath, L. W., and Hurtado, J. (2010). Birds of rice fields in the Americas. *Waterbirds*, 33(1):105–122.

Ali, S., and Ripley, S. D. (1987). Compact handbook of birds of India and Pakistan together with those of Bangladesh, Nepal, Bhutan and Sri Lanka. 2nd ed. *Oxford University Press.* Delhi, p. xlii+737.

Allen, A. P., Whittier, T. R., Kaufmann, P. R., Larsen, D. P., O'Connor, R. J., Hughes, R. M., Stemberger, R. S., Dixit, S.S ., Brinkhurst, R. O., Herlihy, A. T., and Paulsen, S. G. (1999). Concordance of taxonomic richness patterns across multiple assemblages in lakes of the northeastern United States. *Canadian Journal of Fisheries and Aquatic Sciences*, 56:739-747.

Amir, A., Noor, H. M., and Hambali, K. (2015). Assessing Avian Richness and Diversity in Different Regions of Oil Palm Plantation in Selangor, Malaysia. *International Letters of Natural Sciences*, 42:28-37.

Bibby, C. J., Burgess, N. D., Hill, D. A., and Mustoe, S. (2000). Bird Census Techniques. 2nd ed. *Academic Press. New York*.

Blake, J. G., and Loiselle, B. A. (2001). Bird assemblages in second-growth and old-growth forests, Costa Rica: Perspectives from mist nets and point counts. *The Auk*, 118(2): 304–326.

Chace, J. F., and Walsh, J. J. (2006). Urban effects on native avifauna: A review. *Landscape Urban Plan*, 7, 46–69.

Chen, I. C., Hill, J. K., Ohlemuller, R., Roy, D. B., and Thomas, C. D. (2011). Rapid range shifts of species associated with high levels of climate warming. *Science*, 333: 1024–1026.

Comín, F. A., Romero, J. A., Hernández, O., and Menéndez, M. (2001). Restoration of wetlands from abandoned rice fields for nutrient removal, and biological community and landscape diversity. *Restoration Ecology,* 9(2): 201–208.

Crooks, K. R., Suarez, A. V., and Bolger, D. T. (2004). Avian assemblages along a gradient of urbanization in a highly fragmented landscape. *Biological Conservation*, 115: 451-462.

Dal, P. and Vaghela, A. K. (2015). Preliminary survey of avifaunal diversity around Shetrunji River, Dhari, India. *Journal of Biology and Earth Sciences*, 5(1): 19-24.

Dugan, P. J. (1990). Wetland conservation. A review of current issues and required action: IUCN, Gland, Switzerland, p. 96.

Grimmett, R., Inskipp, C., and Inskipp, T. (1998). Birds of the Indian Subcontinent. *Oxford University Press*. New Delhi, 888.

Halder, R. R. (2010). A photographic guide to Birds of Bangladesh. *Baikal Teal Production*. Dhaka Bangladesh. p. 257.

Hansen, A. J., Knight, R. L., Marzluff, J. M., Powell, S., Brown, K., Gude, P. H., and Jones K. B. (2005). Effects of exurban development on biodiversity: patterns, mechanisms, and research needs. *Ecological Application*, 15: 1893–1905.

Hutto, R. L. (1985). Habitat selection by nonbreeding, migratory land birds. In: M. L. Cody (ed.) Habitat Selection in Birds. *Academic Press, Inc. Orlando, Florida,* 455-476.

Islam, S. N. (2010). Threatened Wetlands and ecologically sensitive ecosystems management in Bangladesh. *Frontiers of Earth Science*, 4(4):438-448.

Ismail, A., Rahman, F., and Zulkifli, S. Z. (2012). Status, Composition and Diversity of Avifauna in the Artificial Putrajaya Wetlands and Comparison with its Two Neighboring Habitats. *Tropical Natural History*, 12(2): 137-145.

IUCN Bangladesh. (2015). Red List of Bangladesh. Volume 3: Birds. IUCN, International Union for Conservation of Nature, Bangladesh Country Office, Dhaka, Bangladesh. xvi+676.

Khan, S. I., and Ahsan, M. F. (2011). Birds of the Madhupur National Park, Bangladesh. *Bangladesh Journal of Zoology,* 39 (1): 49-53.

Khan, M. A. R. (1982). Wildlife of Bangladesh-a checklist. *University of Dhaka*. Dhaka, Bangladesh, iv+174.

King, S., Elphick, C. S., Guadagnin, D., Taft, O., and Amano, T. (2010). Effects of landscape features on waterbird use of rice fields. *Waterbirds*, 33: 151–159.

Kumar, A. B. (2006). A checklist of avifauna of the Bharathpuzha river basin, Kerala. *Zoos' Print*, 21(8): 2300-2355.

Kumar, P., Rai, D., and Gupta, S. K. (2016). Wetland bird assemblage in rural ponds of Kurukshetra, India. *Waterbirds*, 39(1): 86–98.

Lameed, G. A. (2011). Species diversity and abundance of wild birds in Dagona-Waterfowl Sanctuary Borno State, Nigeria. *African Journal of Environmental Science and Technology*, 5(10):855-866.

Luo, K., Zhaolu, W., Bai, H., and Wang, Z. (2019). Bird diversity and waterbird habitat preferences in relation to wetland restoration at Dianchi Lake, south-west China. *Avian Research*, 10:21.

Mahabal, A. (2005). Aves. In: The Director (ed.). Fauna of Western Himalaya. *Zoological Survey of India, Kolkata*, 275–339.

McKinney, M. L., and Lockwood, J. L. (2001). Biotic homogenization: a sequential and selective process. In: Lockwood J. L., Mckinney M. (eds.). *Biotic Homogenization, Kluwer Academic, New York*, 1-17.

Mukhopadhyay, S., and Mazumdar, S. (2017). Composition, diversity and foraging guilds of avifauna in a suburban area of southern West Bengal, India. *Ring*, 39:103-120.

Obateru, F. B., Odewumi, O. S., Ogunjemite, B. G., and Agbelusi, E. A. (2019). Diversity and abundance of avian species of Loburo forest (Redemption camp), Ogun State, Nigeria. *Journal of Research in Forestry, Wildlife and Environment*, 11(4):1-10.

Pellissier, V., Cohen, M., Boulay, A., and Clergeau, P. (2012). Birds are also sensitive to landscape composition and configuration within the city centre. *Landscape Urban Plan*. 104, 181–188.

Pickett, S. T. A., Cadenasso, M. L., Grove J. M., Nilon C. H., Pouyat R. V., Zipperer W. C., and Costanza, R. (2001). Urban ecological systems: linking terrestrial ecological, physical, and socioeconomic components of metropolitan areas. *Annual Review* of *Ecology*, *Evolution*, and Systematics, 32: 127–157.

Rajashekara, S., and Venkatesha, M. G. (2014). Insectivorous bird communities of diverse agro-ecosystems in the Bengaluru region, India. *Journal of Entomology and Zoology Studies*, 2(5): 142–155.

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

Rapoport, E. H. (1993). The process of plant colonization in small settlements and large cities, In: McDonnell, M. J. and Pickett, S .T. A. (eds.), Humans as Components of Ecosystems: The Ecology of Subtle Human Effects and Populated Areas, New York: *Springer*, 190–207.

Roy, D., Sarker, S., Mustari, S., Roy, K., Khan, M. A. R, and Latifa G. A. (2022). Exploration of fishing activities, fish species assemblage and diversity status of the largest wetland (Arial Beel) near the capital city in Bangladesh: Implications and conservation. *Acta Ecologica Sinica*, 42(3):243-253.

Sánchez-Bayo, F. (2011). Impacts of agricultural pesticides on terrestrial ecosystems. In: Sánchez-Bayo, F., van den Brink, P. J. and Mann, R. M. (eds.) *Ecological Impacts of Toxic Chemicals*. *Bentham Science Publishers*, 63-87.

Sánchez-Bayo, F., Ward, R., and Beasley, H. (1999). A new technique to measure bird's dietary exposure to pesticides. *Analytica Chimica Acta*, 399:173-183.

Sekercioglu, C. H., Primack, R. B., and Wormworth, J. (2012). The effects of climate change on tropical birds. *Biological Conservation*, 148: 1-18.

Siddique, A. R. 2011. Possible impacts of land use change on eco-hydrology of Arial Beel. 4th Annual Paper Meet and 1st Civil Engineering Congress, December 22-24, 2011, Dhaka, Bangladesh.

Soka, G. E., Munishi, P. K. T., and Thomas, M. B. (2013). Species diversity and abundance of Avifauna in and around Hombolo Wetland in Central Tanzania.*International Journal of Biodiversity and Conservation*, 5(11):782-790.

Sritharan, S., and Burgess, N. D. (2012). Protected area gap analysis of important bird areas in Tanzania. *African Journal of Ecology*, 50:66-76.

Stafford, J. D., Kaminski, R. M,. and Reinecke, K. J. (2010). Avian foods, foraging and habitat conservation in world rice fields. *Waterbirds*, 33(sp1): 133–150.

Surana, R. (2007). Avian diversity during rehabilitation stage of Chimdi Lake, Sunsari Nepal. *Our Nature*, 5(1): 75-80.

Sutherland, W. J. (2006). *Ecological Census Techniques a handbook*. *Cambridge University Press, New York*, xv+450.

Tanalgo, K. C., Pineda, J. A. F., Agravante, M. E., and Amerol, Z. M. (2015). Bird Diversity and Structure in Different Land-use Types in Lowland South-Central Mindanao, Philippines. *Tropical Life Sciences Research*, 26(2): 85–103.

Thakur, M. L., Mattu, V. K., Lal, H., Sharma, V. N., Raj, H., and Thakur, V. (2010). Avifauna of Arki Hills, Solan (Himachal Pradesh), India. *Indian Birds*, 5: 162-166.

Torre-Cuadros, M. D. L. A. L., Herrando-Perez, S., and Young, K. R. (2007). Diversity and structure patterns for tropical montane and premontane forests of central Peru, with an assessment of the use of higher-taxon surrogacy. *Biodiversity Conservation*, 16: 2965-2988.

Tourenq, C., Bennetts, R. E., Kowalski, H., Vialet, E., Lucchesi, J. L., Kayser, Y., and Isenmann, P. (2001). Are ricefields a good alternative to natural marshes for waterbird communities in the Camargue, southern France? *Biological Conservation*, 100(3): 335–343.

Vijayan, L., Prasad, S. N., Sridharan, N., and Guptha, M. B. (2006). Status of Wetlands and Wetland Birds in Selected Districts of Tamilnadu. Sálim Ali Centre For Ornithology & Natural History, Coimbatore.

Yallop, M. L., Connell, M. J., and Bullock, R. (2003). Water birds Herbivory on a newly created wetland complex: Potential implication for site management and habitat creation. *Wetland Ecology and Management*, 12:395-408.

Yashmita-Ulman, and M. Singh. (2022). Avifaunal diversity in unprotected wetlands of Ayodhya district, Uttar Pradesh, India. *Journal of Threatened Taxa*, 14(8): 21561–21578.

Zakaria, M., Rajpar, M. N., and Sajap, A. S. (2009). Species Diversity and Feeding Guilds of Birds in Paya Indah Wetland Reserve, Peninsular Malaysia. *International Journal of Zoological Research*, 5(3): 86-100.

Zakaria, M., and Rajpar, M. N. (2010). Bird Species Composition and Feeding Guilds Based on Point Count and Mist Netting Methods at The Paya Indah Wetland Reserve, Peninsular Malaysia. *Tropical Life Science Research*, 21(2): 7–26.

Zakaria, M. and Rajpar, M. N. (2013). Density and diversity of waterbirds and terrestrial birds in manmade marsh, Malaysia. *Sains Malaysiana*, 42: 1483- 1492.

Zedler, J. B., and Kercher, S. (2005). Wetland resources: status, trends, ecosystem services, and restorability. *Annual Review of Environmental Resources*, 30: 39-74.