TEMPORAL VARIATION, HABITAT HETEROGENEITY AND ANTHROPOGENIC STRESSORS INFLUENCING WILDLIFE COMMUNITIES IN AN OXBOW SHAPED WETLAND OF LOWER GANGES FLOODPLAIN IN BANGLADESH

Jaman, M. F., M. M. Alam, M. F. Rabbe and A. R. Shome*

Wildlife Research Laboratory, Department of Zoology, University of Dhaka, Dhaka-1000, Bangladesh

*Corresponding author: shomear61@gmail.com

Abstract

Marjat *baor* is an Ecologically Critical Area located at the lower Ganges floodplain of Bangladesh. A yearlong study wildlife status, community structure and seasonal effect were made following direct field observation in the Marjat *baor*. A total of 186 vertebrate wildlife species (14 amphibians, 21 reptiles, 131 birds and 19 mammals) were recorded with 9402 individuals. Wetland habitat specialist species were abundant in the community where, *Dendrocygna javanica* was at the top (5.85%). Herpetofauna showed more uneven distribution than the other animal groups. Due to the richness of migratory birds, seasonal variation showed the highest number of unique species in winter season. A significant difference observed between the community structure of human-dominant and non-dominant landscapes in the ANOSIM test ($R = 0.146, p < 0.021$) and NMDs plot. Floating plant and homestead forest around the *baor* held the maximum wildlife species. Species richness ($F=11.334, p=0.0009$) and abundance ($F=68, p= 0.0021$) differed significantly among the five microhabitats of the study area. The presence of eight threatened wildlife species was noticed in the study area. Anthropogenic stressors causes existential crisis for wildlife. It is revealed that, the community-based conservation may be helpful for conserving the wildlife species in the study area. This study may play a significant role in taking future conservation initiatives.

***Key words*:** ECA; *Baor*; Community structure; Habitat; Season; Threats; Conservation.

INTRODUCTION

Wetlands are good productive ecosystems in their socio-economical as well as ecological values (Arya *et al.* 2020). The biodiversity of wetlands plays important roles as they support numerous food webs and rich diversity (Alam *et al.* 2015). Some of the major roles by wetland ecosystems include pollutant filter, food source, climate change mitigation, protection from natural hazards, building materials *etc*. It provides services, such as ecotourism, recreation, spiritual, aesthetic, education and scientific information (Mitsch and Gosselink 2000). For the opulent diversity of flora and fauna, wetlands can be considered as ‘hotspots’ both for wildlife and for the people who are economically dependent on wetlands (Nishat 1993).

Wetlands cover about 19.56% (2.90 million hectare) areas of Bangladesh and during rainy season 50% area turn into seasonal water body (Khan 2018). The wetlands of Bangladesh include *haors* (bowl shaped shallow depression), *baors* (oxbow lakes), *beels* (deeper part of the floodplain), ponds and dighis, floodplains, natural lakes, man-made reservoir (Kaptai lake), coastal (Sundarbans) and marine (St. Martin’s coral island) areas *etc*. (IUCN Bangladesh 2015b) which they are home of a number of wildlife species.

Oxbow lake is a water body, situated on a river's floodplain and is produced when a river bank forms across the neck of a well developed meander (Constantine and Dunne 2008, Mandal and Siddique

2018). Approximately, 6% of the earth's surface is covered by such lakes (Acreman and Holis 1996). An oxbow lake's environment is typically associated with a river and is conducive to the growth of a variety of fauna and flora (Stella *et al*. 2011). Oxbow lakes are thus classified as ecological hotspots, with numerous birds, mammals, fish, amphibians, insects, and plants (Buckton 2007). These wildlife species rely on wetlands for food, breeding, and nesting (Kumar and Gupta 2013). In the lower-Ganges the floodplain of southwestern Bangladesh (Jessore, Jhenaidah, Faridpur, Kustia, Chuadanga and Khulna districts), there are 86 oxbow lakes, locally known as *baor,* which encompass 5,488 ha area (Rahman 2005).

Marjat *baor* is an oxbow lake situated in the Ganges floodplain of south-western Bangladesh and declared as an ECA in 1995 (DoE 2015) which has been playing an important role in socio-economic sector of this area (Bappa *et al.* 2014). As a natural wetland, oxbow lakes are full of wildlife resources. They are overlooked even by the researches. This work attempted to provide a baseline data of the wildlife of Marjat *baor* including their association with wetlands, effects of habitat heterogeneity, seasonal variation and major threats.

MATERIAL AND METHODS

Study area

This study was conducted in an oxbow shaped wetland of lower Ganges floodplain, locally known as Marjat *baor* (23.30919 N, 89.069975 E) (Fig. 1). It is located at Kaliganj upazila, Jhenaidah which is an Ecologically Critical Area (ECA) (Khan 2018) as well as a locally familiar tourist spot. It is the widest *baor* (average 0.66 km wide) which is 7.50 km in length and an oxbow shaped structure formed like an arm from the Bhairab river (Bappa *et al.* 2014) (Fig. 1).

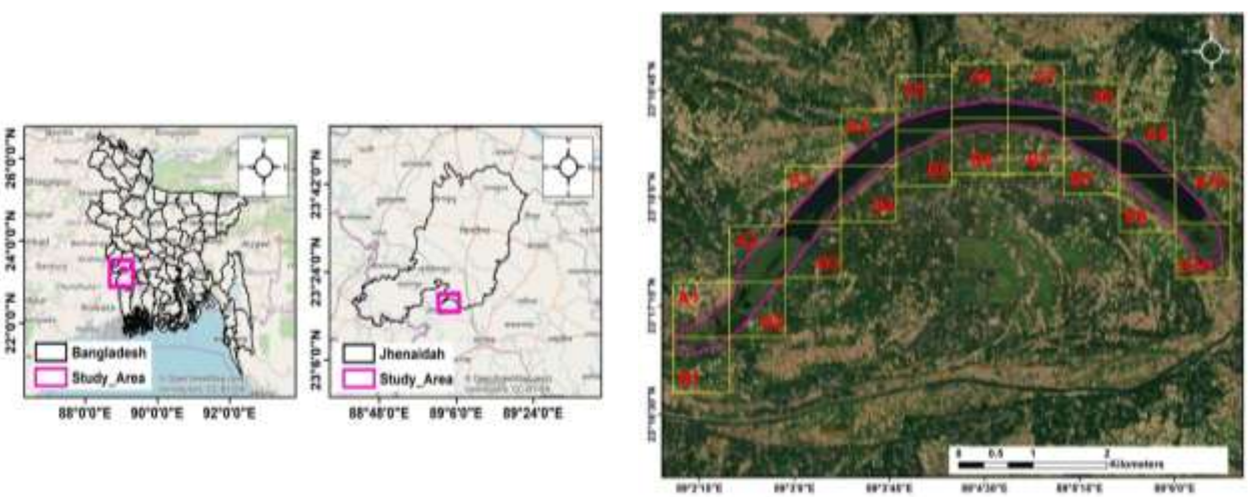


Fig. 1. Map of the study area in Marjat *baor* with created grid.

Fourteen villages are situated surrounding the bank of the *baor* and it is used for agricultural purposes, homestead forest, human habitation and fish culture. The *baor* is full of water in wet season and just after monsoon it starts to dry up and water volume lowers. Fishing and fish culture is one of the major occupations of the people around the *baor*. The study area was divided into two main sites according to habitat structure (Table 1and Fig. 1).

Table 1. Study sites at Marjat *baor*, Jhenaidah.

Sites	Area	Habitat
HD	Human dominated landscape	Human settlement, roadside, homestead forest, agricultural land, fallow land, water body, floating plant
HND	Human not dominated landscape	Water body, floating plant, homestead forest, fallow land, grassland, agricultural land, bushy area

Survey method

Direct field observation method was applied for conducting this year long (November 2019 to October 2020) wildlife survey in the Marjat *baor*. Direct field observation was conducted in the early morning (6.30 am to 10.00 am) and afternoon (3.30 pm to 6.00 pm). For collecting the data of nocturnal wildlife, night survey was conducted using a hand torch and a head torch at night (7.00 pm to 9.00 pm). The study period was divided into three seasons: winter (November to February), summer (March to June) and rainy (July to October) for data collection to evaluate the seasonal variations of the wildlife (Shome *et al.* 2021a, b). A total of 24 days (eight days in each season) were spent in the field to collect data on species diversity, population status, abundance and distribution of wildlife in different habitats. To identify the threats to the wildlife, direct field observation along with perception data of people towards wildlife was collected by eight focus group discussions (FGDs) within the study area. To detect the trade of wildlife, regular field visits in the local market were conducted.

Field survey

The study area was divided into 20 grids (equal number in both sides) by using ArcGIS software Pringle (1984) and Krebs (2009) with the size of 710m×750m. During the field visit the particular grids were identified by using a Garmin eTrex 10 Global Positioning System (GPS). Each grid was surveyed two time in a season by following transect line (500m×30m in size, one in each grid) and boat survey method. The tracing of wildlife was done by hearing and recording their songs and calls, and later the identification was carried out by visual encounter. Data on species diversity, population status, habitats and threats were collected separately in every grid.

Table 2. Observed microhabitats in the study area.

Types	Description
Floating plant (FP)	The aquatic plants are in and around the *baor* were considered as floating plant. Aquatic flora like Water lettuce (*Pistia stratiotes*), Water chestnut (*Trapa bispinosa*), Straight vallisneria (*Vallisneria spiralis*), Water lily (*Nymphaea* spp.), Water spinach (*Ipomoea aquatica*), Helenchaa (*Enhydra fluctuans*), Naiads (*Najas* sp.), Golden bladderwort (*Utricularia aurea*), Asian water grass (*Hygroryza aristata*), Water caltrop (*Trapa maximowiczii*), Water thymes (*Hydrilla verticillata*), Curly leaf pondweed (*Potamogeton crispus*), Duck-potato (*Sagittaria* sp.), Water milfoils (*Myriophyllum* sp.), Hornwort (*Ceratophyllum* sp.), Knotweed (*Polygonum* sp.), Water plantains (*Alisma* sp.), Pond weed (*Potamogeton* sp.) were present here and in the HND site their abundance was higher. Water hyacinth was the prominent floating plant of the HD side of *baor*. Submerged and floating bamboo sticks used for fish culture were also categorized under floating plant.

Open water-body (WB)	The area of water body which has generally deep water (1-2.5 meter) and not dry during dry season. The main portion of *baor*. Presence of aquatic plants is little.
Agricultural land (AG)	One of the major portions of the area around the Marjat *baor* is agricultural land which is a suitable habitat for a number of wildlife species. Different types of crops and vegetables are cultivated here throughout the year.
Homestead Forest (HF)	The adjacent area of the Marjat *baor* is enriched with different types of native plant species, such as Coconut (*Cocos nucifera*), Mango (*Mangifera indica*), Rain tree (*Samanea saman*), Sil koroi (*Albizia procera*), Bamboo (*Bambusa* sp.), Giant thorny bamboo, (*Bambusa arundinacea*), Banana (*Musa paradisiaca*), Areca nut (*Areca catechu*), Velvet apple (*Diospyros* sp.), Banyan tree (*Ficus benghalensis*), Drumstick tree (*Moringa oleifera*), Dumur (*Ficus* sp.), Mahogany (*Swietenia mahagoni*), Jackfruit (*Artocarpus heterophyllus*), Royal poinciana (*Delonix regia*), Wild cinchona (*Anthocephalus chinensis*), Krishna siris (*Albizia richardiana*), Monkey pod (*Albizia lebbeck*), Neem (*Azadirachta indica*), India rubber plant, (*Ficus elastica*), Palmyra palm (*Borassus flabellifer*) which were generally under planted forest or homestead forest.
Human-habitation (HH)	The human settlement is the dominant landscape as well as nearby roadside, ponds, ditches where human activities are higher. The herbs, shrubs, trees contiguous to the human habitat also included this type of habitat.

As a wetland, aquatic habitat was the prominent features of the study area, but there are also some other types of habitat present surrounding the *baor*. The dominant habitats were categorized under three macro (arboreal, terrestrial and aquatic) and five microhabitats which are floating plant (FP), homestead forest (HF), water body (WB), human habitation (HH) and agricultural land (AG) (Table 2).

Data analysis: For statistical analyses of the collected data MS Excel, R- ggplot2 package (version 4.0.5, R Core Team 2020), and PAST (version 4.07) were used. To assess the local abundance of each wildlife species, Khan (2015) was used which is based on the overall occurrences per survey attempt and where 80-100% occurred species is considered as very common (VC), 50-79% common (C), (FC), 20-49% uncommon, and 10-19 % few (F). For estimating the total number of species in the study area and to confirm sampling accuracy, first and second-order Jackknife, Bootstrap, and Chao richness estimators (available in the Vegan Package's specpool' function) were used (Oksanen *et al.* 2019). The estimated number of species (x), was calculated by averaging these four factors according to Fils *et al.* (2014). Following the formula sampling completeness was calculated.

$$\text{Sampling completeness} = \frac{\text{Number of observed wildlife species (n)}}{\text{Estimated number of wildlife species(x)}} \times 100$$

Species relative abundance was measured by following the formula -

$$\text{Relative abundance (RA)} = \frac{\text{Number of individual of a species}}{\text{Total number of individuals of all wildlife species}} \times 100$$

A cluster analysis or habitat similarity plot for microhabitats was created using the Bray-Curtis index (1957), as well as a Non-metric Multi-Dimensional Plot (NMDs) for the two study sites. A rank abundance plot was created in the following by Whittaker (1965) to depict dominance patterns. Shannon-Wiener (Shannon and Wiener 1949) and Simpson's indices (Simpson 1949) were applied to compute the diversity indices. Evenness was determined by dividing the Shannon-Wiener index value by the natural log of species richness. Among the five micro-habitats, correlation between habitats was performed by taking the species diversity as an independent variable and the habitats as the dependent variable. Species richness and total bird abundance in five micro-habitats and seasons were compared with one-way ANOVAs, followed by Tukey's Honest Significant Difference (HSD) test for multiple comparisons ($\alpha = 0.05$).

RESULTS AND DISCUSSION

A total of 186 vertebrate wildlife species observed from the Marjat *baor*, Jhenaidah district (Table 3). The species composition comprised of 14 (7.5%) species of amphibians, 21 (11.82%) reptiles, 131 (70.43%) birds and 19 (10.21%) mammals. A total of 9402 individuals of wildlife were counted from the study area where 564 individuals (6%) were amphhibian, 154 (1.6%) reptiles, 8350 (88.81%) aves and 334 (3.59%) mammals. The observed amphibian species belonged to four families under one order only. The family Dicroglossidae contained the highest number of amphibian species (9 species, 64.28%). *Euphlyctis kalasgramensis* was the most abundant species (n=174, 30.85%). The 21 reptilian species were recorded under two orders and 10 families. The family Colubridae had the highest number of species (6 species, 27.27%). *Hemidactylus frenatus* was the top abundant species in the study area (n=38, 29.87%). Avian species belonged to 17 orders and 47 families. The order Passeriformes (42 species, 32.06%) and the family Accipitridae (12 species, 9.16%) had the maximum bird species. Among birds, *Dendrocygna javanica* was the most abundant species (6.57%). Nineteen (19) mammalians were recorded under four orders and 12 families. Of them, order Muridae (6 species, 30%) held the highest number of species. *Pteropus giganteus* was the topmost aboundant (n=57, 17.26%) species. According to the prediction of the richness estimators, wildlife species range is 190-216 which is relatively close to the observed result confirming 90% sampling. This indicates that species sampling was adequate in the study area.

Table 3. The species observed in wildlife status from Marjat *baor*.

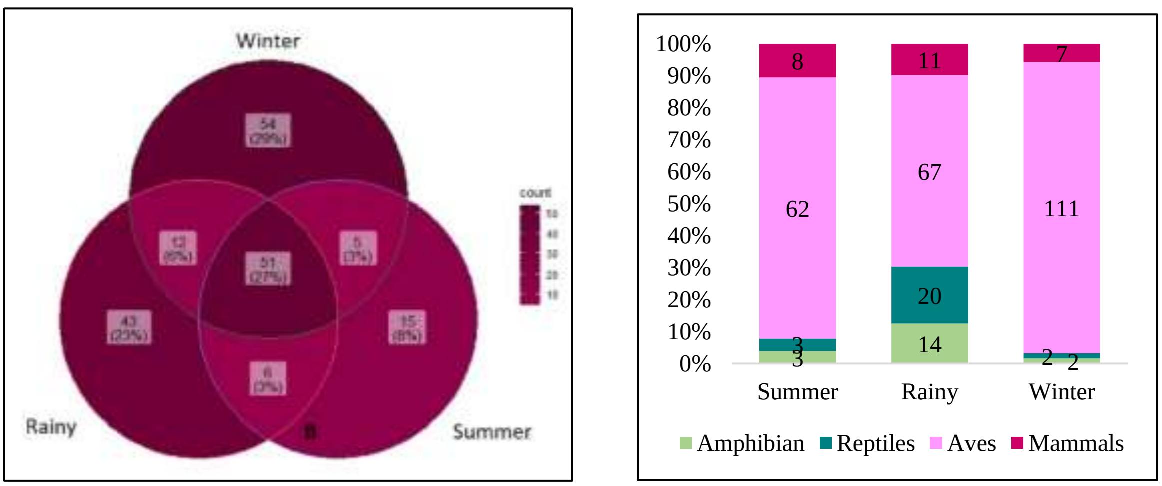
SN	Se	Si	Mi	RA	OS	SN	Se	Si	Mi	RA	OS
					Amphibian						
Euphlyctis cyanophlyctis	Y	HD	AG	30.85	VC	*Fejervarya syhadrensis*	R	HND	AG	2.13	F
Duttaphrynus melanostictus	Y	HND	FP	22.87	VC	*Fejervarya teraiensis*	R	HND	AG	1.60	F
Euphlyctis hexadactylus	R	HND	FP	1.06	F	*Hoplobatrachus tigerinus*	R	HND	AG	3.19	F
Euphlyctis kalasgramensis	R,S	BS	FP	27.13	VC	*Hylarana leptoglossa*	R	HD	FP	1.60	F
Fejervarya asmoti	R	HND	AG	1.06	F	*Hylarana tytleri*	R	HND	AG	2.13	F
Fejervarya nepalensis	R	HND	AG	3.72	F	*Kaloula taprobanica*	R	HD	FP	0.53	F
Fejervarya pierrei	R	HND	AG	1.06	F	*Mycrohyla sp.*	R	HD	HF	1.06	F
					Reptiles						
Ahaetulla nasuta	S	HD	FP	1.95	F	*Indotyphlops braminus*	R	HD	HH	1.95	F
Amphiesma stolatum	R	HND	HF	1.95	F	*Lissemys punctata*	R	HD	HF	1.30	UC
Calotes versicolor	R,S	BS	AG, HF	11.69	C	*Lycodon aulicus*	R	HND	AG	3.90	F
Coelognathus radiatus	S	HND	HF	0.65	F	*Naja kaouthia*	R	HND	FP	1.95	F
Dendrelaphis pictus	R	HND	HF	1.95	F	*Naja naja*	R	HD	FP	0.65	F
Enhydris enhydris	R	HND	FP	1.95	F	*Pangshura tecta*	R	BS	FP, WB	1.30	UC
Eutropis carinata	R	BS	HH	9.74	UC	*Ptyas mucosa*	R	HD	AG	3.90	F
Eutropis macularia	R	HD	HH	1.95	F	*Typhlops diardii*	R	HD	HH	1.95	F
Hemidactylus flaviviridis	R	HD	HH	7.79	UC	*Varanus bengalensis*	R	BS	HF	5.84	UC
Hemidactylus frenatus	R,W	BS	HH	24.68	C	*Xenochrophis cerasogaster*	R	HD	FP	1.95	F
Xenochrophis piscator	R,W	BS	FP	11.04	C						
					Aves						
Accipiter badius	W	HND	HF	0.07	F	*Ixobrychus sinensis*	Y	BS	FP	1.08	VC
Acridotheres fuscus	Y	BS	AG, HF	1.19	U	*Ketupa zeylonensis*	W	HND	HF	0.01	F
Acridotheres ginginianus	Y	BS	AG, FP, HF	1.33	VC	*Lanius cristatus*	W	HD	HF	0.07	F

Acridotheres tristis	Y	BS	AG, FP, HF	1.22	VC	*Lanius schach*	Y	BS	HF	0.94	VC
Actitis hypoleucos	W	BS	FP	0.72	C	*Lonchura punctulata*	R	HND	HF	0.43	F
Aegithina tiphia	Y	BS	HF	0.86	VC	*Lonchura striata*	R,W	BS	HF	0.61	C
Alcedo atthis	Y	BS	FP	1.33	VC	*Luscinia svecica*	W	HND	AG	0.11	F
Amaurornis phoenicurus	R,S	HND	FP	0.32	UC	*Mareca strepera*	W	HND	WB	0.07	F
Anas crecca	W	HND	WB	0.22	F	*Merops leschenaulti*	W	HD	HF	0.14	F
Anthus rufulus	Y	HND	AG	0.50	C	*Merops orientalis*	Y	BS	AG, FP	3.02	VC
Apus nipalensis	Y	BS	HF	1.55	C	*Merops philippinus*	S	BS	AG	1.33	UC
Ardea alba	W	HND	FP	0.86	UC	*Metopidius indicus*	Y	BS	FP	0.58	C
Ardea cinerea	W	HND	FP	0.14	UC	*Microcarbo niger*	Y	BS	WB	1.26	VC
Ardea intermedia	Y	BS	FP	1.40	VC	*Milvus migrans*	S,W	BS	HF	0.22	UC
Ardea purpurea	W	HND	FP	0.04	F	*Mirafra assamica*	W	HD	AG	0.07	F
Ardeola grayii	Y	BS	FP	4.28	VC	*Motacilla alba*	W	HND	FP	0.14	F
Artamus fuscus	R,S	BS	AG	1.04	VC	*Motacilla citreola*	W	BS	FP	0.25	UC
Athene brama	S,W	BS	HF	0.11	UC	*Motacilla flava*	W	HND	FP	0.07	F
Bubulcus ibis	Y	BS	FP	3.02	VC	*Motacilla madaraspatensis*	R	HD	AG	0.04	F
Butastur teesa	W	HD	HF	0.01	F	*Nectarinia asiatica*	Y	BS	HF	1.87	VC
Butorides striata	W	HND	FP	0.14	F	*Nectarinia zeylonica*	Y	BS	HF	1.40	VC
Cacomantis merulinus	S	HD	HF	0.07	F	*Netta rufina*	W	HND	WB	0.54	F
Caprimulgus macrurus	R	HD	HF	0.07	F	*Nettapus coromandelianus*	R,W	BS	WB	2.09	C
Centropus bengalensis	W	HD	AG	0.07	F	*Ninox scutulata*	W	HD	HF	0.07	F
Centropus sinensis	Y	BS	FP	0.94	VC	*Nisaetus cirrhatus*	R	HND	HF	0.11	F
Ceryle rudis	Y	BS	FP	1.30	VC	*Oriolus xanthornus*	Y	BS	HF	0.83	VC
Charadrius dubius	W	BS	FP	0.43	UC	*Orthotomus atrogularis*	Y	BS	HF	1.12	VC
Chlidonias hybrida	R	HD	FP	0.07	F	*Otus lettia*	W	HD	HF	0.04	F
Circus melanoleucos	W	HND	FP	0.14	F	*Pandion haliaetus*	W	HND	HF	0.07	F
Cisticola juncidis	Y	BS	AG	0.76	C	*Parus major*	R	HD	HF	0.04	F
Clamator jacobinus	S	HD	HF	0.07	F	*Pericrocotus cinnamomeus*	W	BS	HF	0.50	UC
Clanga clanga	W	HND	HF	0.01	F	*Pernis ptilorhyncus*	W	HND	AG	0.04	F
Clanga hastate	W	HND	HF	0.02	F	*Phalacrocorax carbo*	W	HD	WB	0.43	F
Columba livia	Y	BS	AG	2.48	C	*Phylloscopus fuscatus*	W	HD	HF	0.18	F
Copsychus saularis	Y	BS	AG, HF	0.94	VC	*Picus xanthopygaeus*	R,W	BS	HF	0.22	UC
Coracias benghalensis	Y	BS	AG, HF	0.58	VC	*Pluvialis fulva*	W	HND	FP	0.54	F
Corvus levaillantii	S	HD	AG	0.11	F	*Porphyrio porphyrio*	W	HND	FP	0.07	F
Corvus splendens	W	HD	AG	0.07	F	*Psilopogon asiaticus*	Y	BS	HF	0.29	C
Cuculus micropterus	R	HD	HF	0.07	F	*Psilopogon haemacephala*	Y	BS	HF	0.65	VC
Cypsiurus balasiensis	Y	BS	AG, HF	3.13	VC	*Psilopogon lineatus*	Y	BS	HF	0.61	VC
Dendrocitta vagabunda	Y	BS	HF	0.50	C	*Psittacula cyanocephala*	S	HND	HF	0.11	UC
Dendrocopos macei	Y	BS	HF	0.76	VC	*Psittacula krameri*	S	HND	HF	0.07	F
Dendrocygna bicolor	W	HND	WB	0.18	F	*Pycnonotus cafer*	Y	BS	AG, HF	2.12	VC
Dendrocygna javanica	Y	BS	WB	6.59	VC	*Rhipidura albicollis*	R	HND	HF	0.11	F
Dicrurus aeneus	W	HND	HF	0.11	F	*Rostratula benghalensis*	W	HND	FP	0.07	F
Dicrurus macrocercus	Y	BS	AG, HF	1.91	VC	*Spatula querquedula*	W	HND	WB	0.07	F
Dinopium benghalense	S,W	HND	HF	0.11	UC	*Spilopelia chinensis*	Y	BS	AG	4.07	VC
Egretta garzetta	Y	BS	FP	3.96	VC	*Spilornis cheela*	S	HD	HF	0.01	F
Elanus caeruleus	Y	BS	AG	0.97	VC	*Streptopelia decaocto*	Y	BS	AG	1.19	VC
Eudynamys scolopaceus	Y	BS	HF	0.83	VC	*Streptopelia tranquebarica*	Y	BS	AG	0.90	VC
Ficedula albicilla	W	HND	AG	0.29	F	*Sturnus contra*	Y	BS	AG, FP, HF	1.91	VC
Fulica atra	W	HND	FP	0.11	F	*Sturnus malabaricus*	Y	BS	HF	1.22	C
Gallicrex cinerea	R,W	HND	FP	0.18	UC	*Tachybaptus ruficollis*	W	HND	FP, WB	1.04	UC
Gallinago Gallinago	W	BS	FP	0.18	UC	*Terpsiphone paradisi*	R	HD	HF	0.07	F
Gallinago stenura	W	HND	FP	0.11	F	*Threskiornis melanocephalus*	R,W	HND	FP	0.07	UC
Gallinula chloropus	W	BS	FP	0.97	UC	*Treron phoenicopterus*	W	HD	HF	0.86	F
Halcyon smyrnensis	Y	BS	FP	1.37	VC	*Tringa glareola*	W	HND	FP	1.98	F
Haliastur indus	S,W	BS	FP	0.11	UC	*Tringa ochropus*	W	BS	FP	0.11	UC
Hierococcyx varius	Y	BS	HF	1.19	VC	*Turdoides earlei*	W	HND	AG	0.54	F
Hirundo fluvicola	W	HND	FP	0.07	F	*Turdoides striata*	Y	HND	HF	0.83	C
Hirundo rustica	R,W	BS	FP	1.76	C	*Upupa epops*	R,W	BS	AG	0.22	C
Hydrophasianus chirurgus	Y	HND	FP, WB	2.27	C	*Vanellus cinereus*	W	BS	AG	1.48	UC
Hypothymis azurea	W	HND	HF	0.11	UC	*Vanellus indicus*	Y	BS	AG	1.80	VC
Ichthyophaga ichthyaetus	S	HD	HF	0.01	F	*Zapornia pusilla*	W	HND	FP	0.04	F
Ixobrychus cinnamomeus	Y	BS	FP	0.29	VC	*Zoothera citrina*	W	HND	HF	0.25	F
Ixobrychus flavicollis	R	HND	FP	0.07	UC						
Mammals											
Bandicota bengalensis	R, W	HD	AG	3.59	UC	*Paradoxurus hermaphroditus*	S	HND	HF	2.69	F
Bandicota indica	W	HD	AG	0.90	F	*Pipistrellus coromandra*	R	BS	HF	4.49	UC
Canis aureus	R	BS	AG	15.27	UC	*Pteropus giganteus*	Y	HD	HF	###	VC
Felis chaus	R	HND	AG	0.30	F	*Rattus norvegicus*	S	HD	HH	1.80	F
Funambulus pennantii	S	HD	HF	2.69	F	*Rattus rattus*	R, W	HD	HH	4.49	UC

Herpestes auropunctatus	R	HD	AG	8.98	UC	*Semnopithecus entellus*	R	HD	HH	4.49	F
Herpestes edwardsii	S	HD	AG	1.80	F	*Suncus murinus*	Y	BS	HH	###	VC
Megaderma lyra	W	HND	HF	2.69	UC	*Viverricula indica*	S	HD	HH	1.80	F
Mus booduga	R	HND	HH	2.69	F	*Vulpes bengalensis*	R,S	HND	AG	6.29	UC
Mus musculus	S,W	BS	HH	5.39	UC						

Note: SN- Scientific name, RA- Relative abundance; OS- Observation status; VC- Very Common; C-Common, UC-Uncommon, Few- FE; M- Micro-habitat, F- Floating plant, HF- Homestead forest, WB- Open waterbody, A- Agricultural land; Se- Season, W-Winter, S-Summer and R- Rainy, Y- Year round; Site- Survey site, HD- Human disturbed area, HND- Human non-disturbed site; *vagrant

Wetlands are important habitats for different group of wildlife (IUCN Bangladesh 2015a) and in the lower Ganges portion of Bangladesh, *baors* play significant role as a part of wetlands (Rahman 2005). Even as an Ecologically Critical Area, conservation of wildlife as well as other faunal group is important (Khan 2018). But, it is well known that there is no previous research work on wildlife in the *baor* of Bangladesh. Some research works in *baor* areas have been done in India focusing avifauna (Chatterjee *et al.* 2023, Mandal *et al.* 2021, Debnath *et al.* 2018). Result from this study showed higher number of avian species in the study area compared to other oxbow lake except Purbasthali, West Bengal, India (Chowdhury 2023).



A B

Fig. 2. A. Venn diagram showing the number of shared and unique species among three seasons; and B. Relative abundance of species richness in different group of wildlife in three seasons.

The effect of temporal variation on wildlife community is noticable in different season. In winter season, species richness (122 species, 65.59%) and abundance (n=4364, 46.41%) was the highest, whereas species richness (76 species, 40.86%) and abundance (n=2136, 22.21%) was the lowest in summer season. The overall comparison of richness and abundance of wildlife species for three seasons were not significantly different (abundance: $F=3.821$, $df=2$, $p=0.1496$) (richness: $F=6.49$, $df=2$, $p=0.081$). Pairwise one-way ANOVA for the species richness and abundance of wildlife showed no significant difference between seasons. Among the total number of wildlife species, 54 (29.03%) unique species were particularly observed during winter season where 51 (27%) species were observed in all three seasons (Fig. 2A). For the presence of migratory birds in higher number, species richness and abundance are the highest in this season (Chowdhury 2023, Shome *et al.* 2022a, Shome *et al.* 2022b) (Fig. 2B). During the winter season, the water level goes down and the *baor* becomes dried which provide more feeding opportunities to different group of wildlife (Ali *et al.* 2016). In rainy season, the aquatic environment of the *baor* was more ancillary for amphibian and reptiles (Fig. 2B) (Mehra *et al.* 2021). Diversity index showed the highest diversity value for rainy season (*H=4.280*, *Ds=0.981*) and species was more evenly distributed in this season (*E=0.651*). The highest abundance of herpetofauna in rainy season was stimulated on the diversity index value (Pal *et al.* 2012).

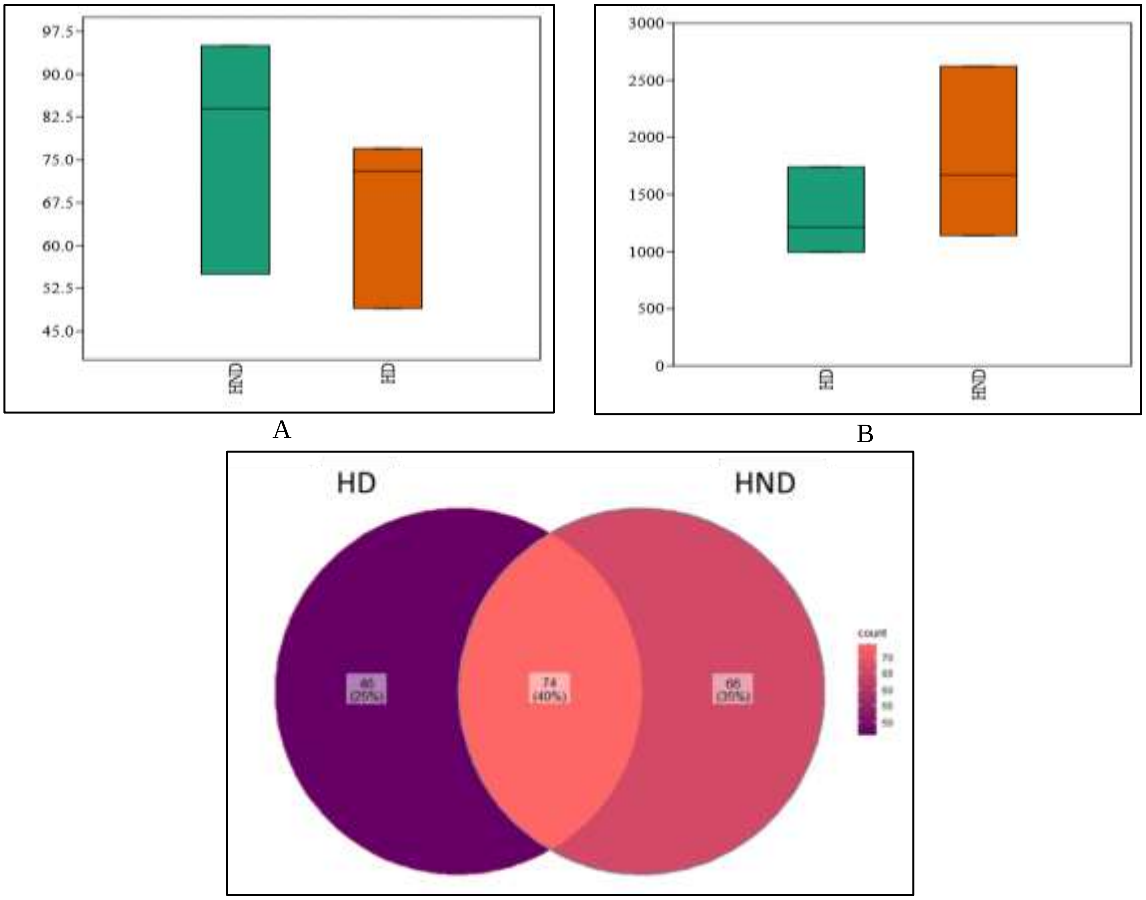


Fig. 3. Boxplots of wildlife: A. Species richness; B. Abundance by study sites per season; and C. Venn diagram showing the number of shared and unique species between two study sites.

The human non-disturbed (HND) site had the highest number of species richness (140 species, 75.26%) and abundance (n = 5436, 57.81%) compared to the human-disturbed (HD) site. The maximum total number of species was observed in the human non-disturbed area (78±20.66) in contrast to the human-disturbed (HD) area (66.33±15.14) (Fig. 3A). A similar result was found for the abundance of wildlife in two study sites per season, as shown in Fig. 3B. The diversity indices also showed the highest value in human non-disturbed area (*H=4.358, Ds=0.981*), where another site showed the highest evenness (*E=0.561*) value. Seventy-four species of wildlife were found in both sites of the study area, with 66 species found particularly in the HND site and 46 in the HD site (Fig. 3C). The HND site had lesser disturbances and anthropogenic activities than HD site (Alvarez-Alvarez *et al.* 2020, Wilbard and Samora 2013). Probably, fewer anthropogenic stressors help to create more wildlife diversity at these study sites. In addition, HND site is more diverse with floating plant and native plant species (Farley *et al.* 2022). Observation status showed 43 (21.62%) very common, 21 the human non-disturbed (HND) site had the highest number of species richness (140 species, 75.26%) and abundance (n = 5436, 57.81%) compared to the human-disturbed (HD) site. The maximum total number of species was observed in the human non-disturbed area (78±20.66) in contrast to the human-disturbed (HD) area (66.33±15.14) (Fig. 3A). A similar result was found for the abundance of wildlife in two study sites per season, as shown in Fig. 3B. The diversity indices also showed the highest value in human non-disturbed area (*H=4.358, Ds=0.981*), where another site showed the highest evenness (*E=0.561*) value. Seventy-four species of wildlife were found in both sites of the study area, with 66 species found particularly in the HND site and 46 in the HD site (Fig. 3C). The HND site has comparatively less disturbances and anthropogenic activities than HD site (Alvarez-Alvarez *et al.* 2020, Wilbard and Samora 2013). Probably, fewer anthropogenic stressors help to create more wildlife diversity at these study sites. In addition, the HND site is more diverse with floating plant and native plant species (Farley *et al.* 2022). Observation status showed 43 (21.62%) very common, 21 (11.34%) common, 32 (18.90%) uncommon, and 90 (48.64%) few wildlife species.

Significant difference (*R=0.146, p<0.021*) was found between the communities of wildlife in the two study sites according to the result of the analysis of similarity (ANOSIM) test as well as in the non-metric multidimensional plot (NMDs) with a stress level of 0.058 (*<0.2*) (Fig. 4).

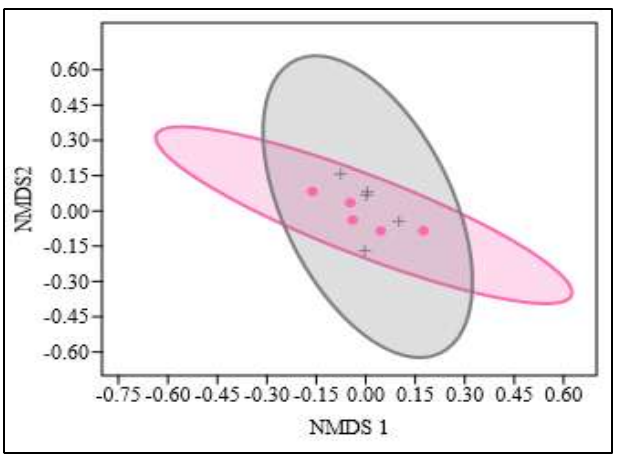


Fig. 4. Separation of wildlife communities between two study sites showing non-metric multidimensional plot (Grey circle and dots indicating the site human non-disturbed and pink indicate human disturbed).

Dendrocygna javanica was the most abundant (5.85%) species among all wildlife in the study area (Fig. 5A). The abundance of this species was also higher on both sites of the study area (HD 5.24%, HND 6.29%) (Fig. 5A). *Dendrocygna javanica* is a wetland specialist bird that feeds mainly on aquatic plants (*e.g.* tubers, shoots, seed, and leaves) and aquatic macro-invertebrates and small vertebrates (Onwuka *et al.* 2020). About 31% of the population were occupied by the 10 most abundant wildlife species, whereas the less abundant 50 species were only 2.10% of the total population. Among the different groups of wildlife, amphibian communities showed the highest uneven distribution of species in the community structure and the three most abundant species (*Euphlyctis kalasgramensis*, *Duttaphrynus melanostictus* and *Euphlyctis cyanophlyctis*) held 80% of the population of the total amphibian community. The less abundant species are at risk of vanishing from the study area. The same result was also observed for reptiles and mammals, where three reptile species dominated covering 48% of the population (*Hemidactylus frenatus, Calotes versicolor* and *Xenochrophis piscator*) and three mammalian species (*Suncus murinus, Pteropus giganteus* and *Canis aureus*) covered 42% of the population (Fig. 5B).

In the avian community, the distribution of species was comparatively even compared to other wildlife groups. About 10% of the most abundant species (13 species: *Dendrocygna javanica, Ardeola grayii, Spilopelia chinensis, Egretta garzetta, Cypsiurus balasiensis, Bubulcus ibis, Merops orientalis, Columba livia, Hydrophasianus chirurgus, Pycnonotus cafer, Nettapus coromandelianus, Tringa glareola* and *Dicrurus macrocercus*) comprised 40% of total bird community (Fig. 5B).

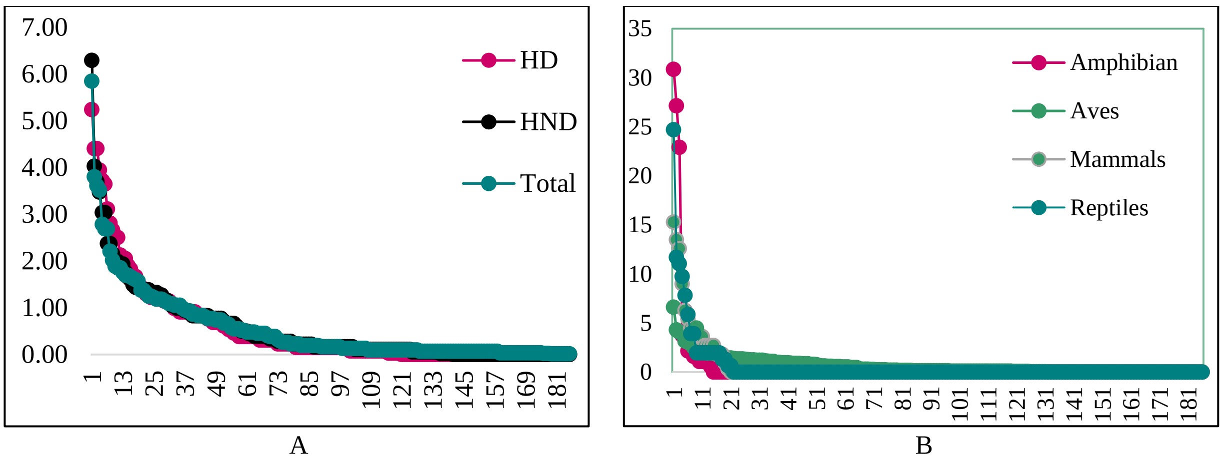


Fig. 5. Rank abundance plot for recorded species: A. total study area along with study sites; B. different groups of wildlife (The y-axis shows the relative abundance, and the x-axis ranks the species in order of their abundance from highest to lowest).

Of the most abundant 10 species, seven were wetland habitat specialist (*Dendrocygna javanica, Ardeola grayii, Egretta garzetta, Bubulcus ibis, Hydrophasianus chirurgus, Euphlyctis kalasgramensis* and *Nettapus coromandelianus*). In every group of wildlife, wetland habitat specialist species dominate. In wetlands habitat, wetlands specialist fauna gets more opportunities (King *et al.* 2006) and as a wetland habitat the Marjat *baor* provides more opportunities for livelihood materials to them. For this reason, a strong uneven distribution of wildlife in the community structure was observed.

Habitat heterogeneity effects on the community structure of the wildlife. Though the highest number of wildlife species (75 species, 40.32%) used arboreal habitat as their macro-habitat, the highest number of populations (n=4308, 45.89%) used aquatic habitat. Homestead forest around the *baor* was the most commonly used microhabitat (75 species, 40.32%), followed by the floating plant (75 species, 29.56%). Most of the population of wildlife species used floating plant as their microhabitat (33.15%). In the HD site, agricultural land (31.89%) was the most used microhabitat, whereas, in the HND site, floating plant (36.60%) was mostly used by the wildlife population (Fig. 6).

Dense homestead forest was surrounded by the Marjat *baor* and native plant species are commonly cultivated here. Plants surrounding the wetlands support terrestrial as well as aquatic wildlife by providing nesting, breeding, resting, and feeding sites. This provides velocity to increase native and migratory wildlife species in this habitat of the study area (Flinn *et al.* 2008, Swift *et al.* 1984). Floating plant diversity is high in the Marjat *baor*, especially at the HND site. Diverse aquatic plant species support diverse types of aquatic wildlife by providing feeding, resting, and breeding sites (Muñoz-Pedreros and Merino 2014). The highest number of amphibians and birds used floating plant as their microhabitat, where mammals and reptiles inhabited forests and human habitations (Fig 6B.).

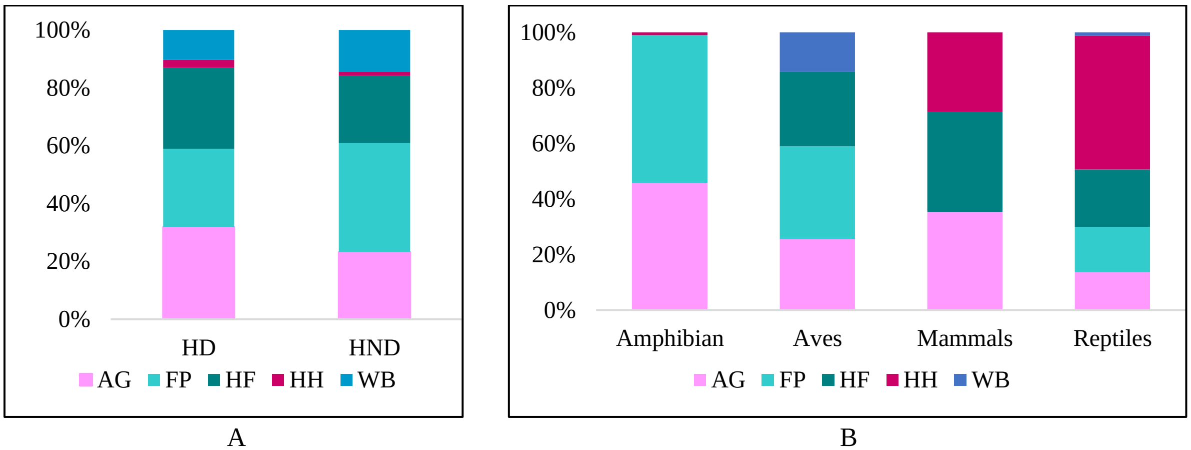


Fig. 6. Relative abundance of wildlife in (A) two sites and (B) different group among five micro-habitats (FP- Floating plant, HH- Human habitation, WB- Waterbody, AG- Agricultural land, HF- Homestead forest).

Amphibian and aquatic birds lead their lives in and around wetlands, and floating plant through collecting their food and nesting materials from here (Muñoz-Pedreros and Merino 2014). So, their number was found higher in floating plant than other microhabitats. When comparing the total richness and abundance, five microhabitats showed significant differences (for richness: $F=11.334$, $df=4$, $p=0.0009$; for abundance: $F=68$, $df=4$, $p=0.0021$). The pair-wise Tukey HSD test for habitats was significant for the pairs with species richness of homestead forest *vs.* human habitation ($F_{HF-HH}=7.52$, $p=0.0021$) along with waterbody ($F_{HF-WB}=7.82$, $p=0.0018$) and floating plant *vs.* human habitation ($F_{FP-HH}=4.91$, $p=0.037$) along with water bodies ($F_{FP-WB}=5.21$, $p=0.027$) in species richness. Considering abundance, population of floating plant vs. human habitation ($F_{FP-HH}=5.394$, $p=0.022$) showed significant variation.

Comparing the diversity indices of the five microhabitats, this study found homestead forests with the highest value ($H=3.727$, $Ds=0.968$) while wildlife was more evenly distributed in human habitation ($E=0.729$). The cluster analysis showed that the species between homestead forest and agricultural land were more similar and formed a small cluster. These two types of microhabitats showed similar types of species with floating plant and formed a second cluster. The second cluster showed less similar species with the species of water body habitat and ultimately formed a larger cluster, and the larger cluster showed more dissimilar species with human habitation (Fig. 7A).

The correlation plot among the communities showed that the wildlife communities of the HF and AG micro-habitats were positively correlated ($r=0.03$, $p<0.05$) (Fig. 7B). Species of HF were negatively correlated with the floating plant ($r = -0.13$, $p<0.05$) (Fig. 7B). The most habitat specialist species (64 species, 64%) were found in the homestead forest habitat, followed by floating plant (47 species, 25%)

(Fig. 7C). Homestead forest and agricultural land are terrestrial types of habitat and are located closely. Thus, the two types of microhabitats shared a higher number of species (Rosin *et al.* 2016).

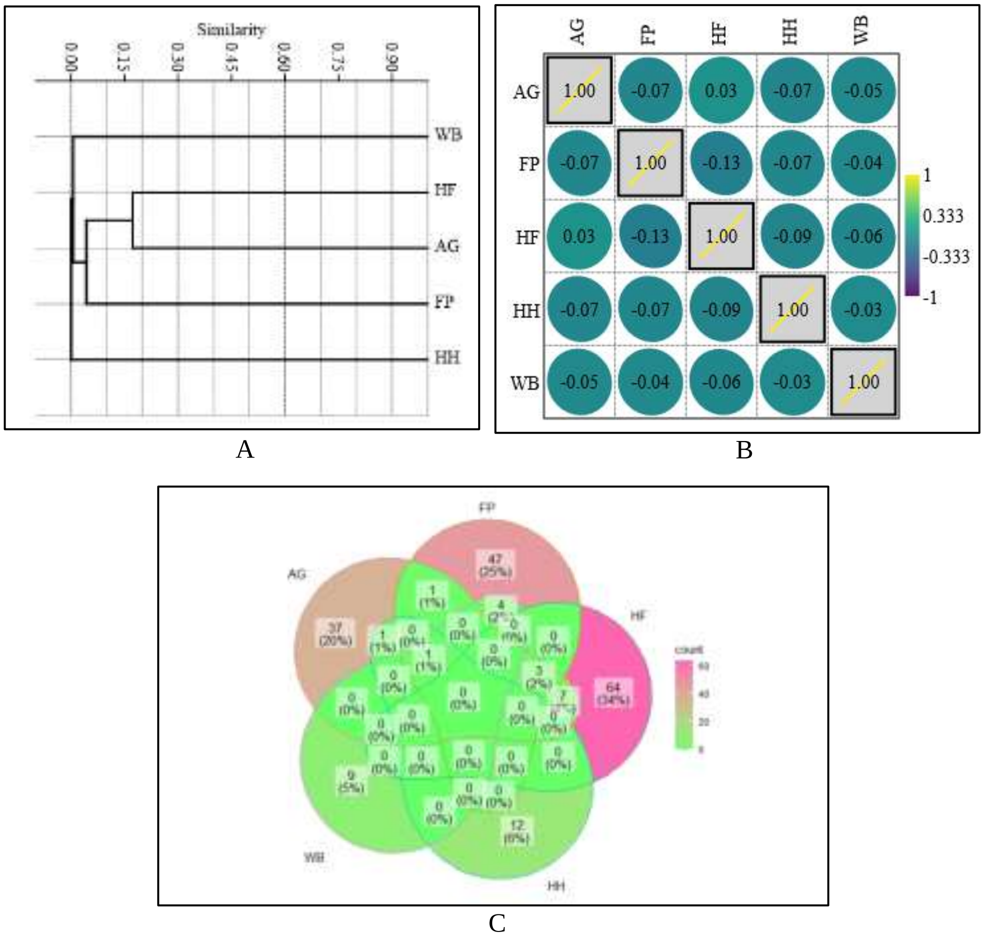


Fig. 7. A. Similarity profile test among microhabitats using Bray-Curtis index; B**.** Correlation plot showing correlations among micro-habitats in the study area; C. Venn diagram showing the number of shared and unique species among five micro-habitats (FP- Floating plant, HH- Human habitation, WB- Water body, AG- Agricultural land, HF- Homestead forest).

This study found two Endangered wildlife species (*Clanga hastata* and *Semnopithecus entellus*), four Vulnerable wildlife species (*Kaloula taprobanica*, *Clanga clanga*, *Threskiornis melanocephalus* and *Vulpes bengalensis*) from the study area according to the IUCN red list assessment of Bangladesh (2015a, b). At the same time, four Near Threatened (*Ichthyophaga ichthyaetus*, *Varanus bengalensis*, *Naja naja* and *Naja kaouthia*) wildlife species were also observed. The rest of the species are categorized as Least Concern (LC) according to the respective assessment.

According to the perception of local people, *Prionailurus viverrinus* (Endangered), *Leptoptilos javanicus* (Vulnerable) was also present in the study area and *Semnopithecus entellus* (Endangered) was vagrant for this area. Therefore, it is clear, this wetland is important for eight threatened wildlife species. During the field study, several threats to wildlife especially for birds, were observed in the study area.

Hunting, trapping and poaching of wetland birds (*e.g.*, *Dendrocygna javanica*, *Ardeola grayii, Egretta garzetta*, *Bubulcus ibis*, *Hydrophasianus chirurgus* and *Nettapus coromandelianus*) were the major problems in this area and during winter those numbers fortify due to the movement of tourists (Shome *et al*. 2022a). Existing fishing practices also create disturbance for wetland birds. Turtles (*Pangshura tecta*, *Lissemys punctata*, and *Morenia petersi*) were also hunted by local people for consumption as well as for trade. The use of agricultural nets for crop protection was another problem for birds (*Spilopelia chinensis, Psittacula krameri, Hirundo rustica, Oriolus xanthornus, Ninox scutulata, Otus lettia* and *Caprimulgus macrurus*) on agricultural land and homestead forests. At that time, human-mammal conflict was observed, and especially small carnivore mammals were at risk (Shome and Jaman 2021). Humans around the study area also have fears, misconceptions, and superstitions about some groups of wildlife, especially snakes, which also stimulate to increase the conflict (Jaman *et al.* 2020). A number of venomous and non venomous snakes were killed by humans, and two recent cases of human deaths due to snakebites were also identified. Local people around the Marjat *baor* have little knowledge of wildlife and biodiversity conservation as well as the status of the area as an Ecologically Critical Area (ECA). Moreover, there was no initiative by the authorities to conserve wildlife in this area.

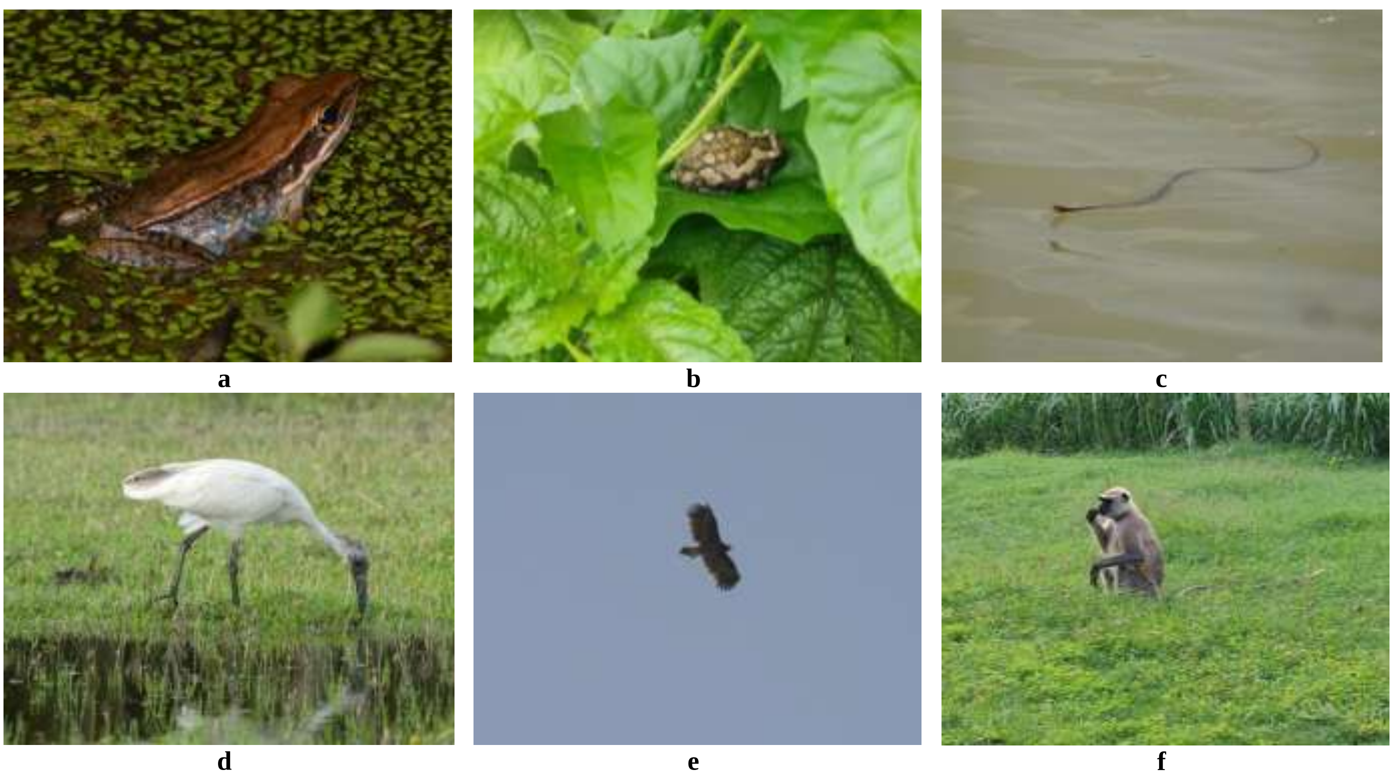


Fig. 8. Representative wildlife species (Class: Amphibia, Reptilia, Aves and Mammalia) of the areas covered by the present study: **a.** *Hylarana leptoglossa*; **b.** *Kaloula taprobanica*; **c.** *Xenochrophis cerasogaster*; **d.** *Threskiornis melanocephalus*; **e.** *Clanga clanga*; and **f.** *Semnopithecus entellus.*

Oxbow lakes in lower Ganges floodplain play significant role inhabiting a number of resident and migratory (birds) wildlife species which appeared in this research findings. For the first time, this study provided the actual scenario along with the baseline information of wildlife resources in the study area.

This study also showed the alpha and beta diversity pattern of wildlife of the study area. The Marjat *baor* supports different wildlife species throughout the year which are associated with these wetlands. Floating plant species and the homestead forest are significant for harboring more unique species in the *baor*. Wetland specialist wildlife is dominant and their relative abundance is higher in the wildlife community of this *baor* for availability of livelihood resources. Though the study area is designated as Ecologically Critical Area (ECA) but unfortunately the wildlife resources are in existential crisis for anthropogenic stressors. Presence of eight species of threatened wildlife species also provide the message for taking rapid conservation initiative. At the same time, community based ecological management is necessary for conserving the wildlife of the *baor*. At present ecofriendly tourism management is essential along with implementation of existing laws against wildlife hunting and poaching. Awareness creation is necessary among local people, tourist, fisherman and school going children. Detailed study is essential on habitat quality, fishing practices, ecosystem services, critical habitat assessment, level of anthropogenic stressors, threat assessment *etc*.

ACKNOWLEDGEMENTS

We express our gratitude to the administration of Kaliganj upazila, Jhenaidah along with the guides, boatman and local people for their assistance in the field. This study was funded by the Ministry of Science and Technology, Government of the People's Republic of Bangladesh.

REFERENCES

Acreman, M. C. and G. E. Hollis. 1996. *Water management and wetlands in Sub-Saharan Africa*. International Union for Conservation of Nature, Gland (Suiza). 249 pp.

Alam, A. B. M. S., M. K. Badhon and M. W. Sarker. 2015. *Biodiversity of Tanguar Haor: A Ramsar Site of Bangladesh Volume III: Fish*. IUCN, International Union for Conservation of Nature, Bangladesh Country Office, Dhaka, Bangladesh. 216 pp.

Ali, E., H. Ismahan and H. Moussa. 2016. Diversity patterns and seasonal variation of the waterbird community in Mediterranean wetlands of Northeastern Algeria. *Zool. Ecol*. **26**: 85-92.

Alvarez-Alvarez, E. A., R. Rodríguez-Godínez, P. Sierra-Morales, S. A. Medina-Valdivia, E. Vázquez-Salgado, M. Brito-Millán and R. C. Almazán-Núñez. 2020. Patterns of bird diversity and endemism along an elevational gradient in the southern Mexican highlands. *Zool. Stud.* **59**: 1-13.

Arya, A. K., K. K. Joshi and A. Bachheti. 2020. A review on distribution and importance of wetlands in the perspective of India. *J. Appl. Nat. Sci*. **12**: 710-720.

Bappa, S. B., M. M. M. Hossain, B. K. Dey, S. Akter and M. Hasan-Uj-Jaman. 2014. Socio-economic status of fishermen of the Marjat *baor* at Kaligonj in Jhenidah district, Bangladesh. *J. Fish.* **2**:100-105.

Buckton, S. 2007. Managing wetlands for sustainable livelihoods at Koshi Tappu. *Damphe.* **16**: 12-13.

Bray, J. R. and J. T. Curtis. 1957. An ordination of the upland forest communities of southern Wisconsin. *Ecol. Monogr.* **27**: 325-349.

Chatterjee, L., A. B. Roy, T. Samanta and B. Mitra. 2023. Assemblage of winter water birds in Chupi Oxbow Lake, Purbasthali, Purba Bardhaman, West Bengal. Bharati Publication, New Delhi, India., pp. 237-250.

Chowdhury, S. 2023. Diversity, Composition and abundance of avian species of oxbow lake and surrounding area in Purbasthali, West Bengal, India. *Int. J. Exp. Res. Rev.* **30**: 306-320.

Constantine, J. A. and T. Dunne 2008. Meander cutoff and the controls on the production of oxbow lakes. *Geol*. **36**: 23-26.

Debnath, S., S. Biswas and A. K. Panigrahi. 2018. Present status and diversity of avian fauna in Purbasthali bird sanctuary, West Bengal, India. *Agric. Sci. Dig. J.* **38**: 95-102.

DoE (Department of Environment). 2015. *Community Based Ecosystem Conservation and Adaptation in Ecologically Critical Areas of Bangladesh: Responding to Nature and Changing Climate.* Department of Environment (DoE), Ministry of Environment and Forests, Dhaka, Bangladesh. 122 pp.

Farley, E. B., M. L. Schummer, D. J. Leopold, J. M. Coluccy and D. C. Tozer. 2022. Influence of water level management on vegetation and bird use of restored wetlands in the Montezuma Wetlands Complex. *Wildlife Biol.* **2022**: e01016.

Fils, E. M. B., A. G. B. A. Anong, D. B. Tsala, B. B. Guieké, D. F. Tsala and A. K. Fotso. 2014 Diversity of bats of the Far North Region of Cameroon-with two first records for the country. *Biodivers*. **15**: 16-22.

Flinn, K. M., M. J. Lechowicz and M. J. Waterway. 2008. Plant species diversity and composition of wetlands within an upland forest. *Am. J. Bot.* **95**: 1216-1224.

IUCN Bangladesh. 2015a. *Red List of Bangladesh Volume 5: Freshwater Fishes.* IUCN, International Union for Conservation of Nature, Bangladesh Country Office, Dhaka, Bangladesh. 360 pp.

IUCN Bangladesh. 2015b. *Red List of Bangladesh Volume 3: Birds.* IUCN, International Union for Conservation of Nature, Bangladesh Country Office, Dhaka, Bangladesh. 676 pp.

Jaman, M. F., M. F. Rabbe, M. M. Alam, A. R. Shome, M. A. Hossain and M. A. R. Sarker. 2020. Students' perceptions on snake in Northwestern Bangladesh. *Asian J. Ethnobiol*. **3**: 62-69.

Khan, M. A. R. 2015. *Wildlife of Bangladesh-checklist and guide*. Chayabithi, Purana Paltan, Dhaka 1000, Bangladesh. 568 pp.

Khan, M. M. H. 2018. *A Photographic Guide to Wildlife of Bangladesh*. Arannayk Foundation, Dhaka, Bangladesh. 488 pp.

King, S. L., D. J. Twedt and R. R. Wilson. 2006. The role of the wetland reserve program in conservation efforts in the Mississippi river alluvial valley. *Wildl. Soc. Bull.* **34**(4): 914-920.

Krebs, C. J. 2009. *Ecology: The Experimental Analysis of Distribution and Abundance.* 6th ed. Benjamin Cummings, United States. 800 pp.

Kumar, P. and S. K. Gupta. 2013. Status of wetland birds of Chhilchhila Wildlife Sanctuary, Haryana, India. *J. Threat. Taxa.* **5**(5): 3969-3976.

Mandal, M. H. and G. Siddique. 2018. Water birds at Purbasthali oxbow lake: A geographical study. *Res. World.* **9**: 7-19.

Mandal, M. H., A. Roy, S. Ghosh, A. Basak and G. Siddique. 2021. Assemblage of wetland birds in Purbasthali Oxbow Lake, West Bengal, India: Implications for Management. *Ornis Hung*. **29**: 25-45.

Mehra, G. S., S. Shrotriya, D. Bisht and S. K. Dutta. 2021. Seasonal variations in the diversity of amphibians and reptiles in Western Terai Arc Landscape, India. *Int. J. Zool. Appl. Biosci.* **6**: 194-202.

Mitsch, W. J. and J. G. Gosselink. 2000. The value of wetlands: importance of scale and landscape setting. *Ecol. Econ.* **35**: 25-33.

Muñoz-Pedreros, A. and C. Merino. 2014. Diversity of aquatic bird species in a wetland complex in southern Chile. *J. Nat. Hist.* **48**: 1453-1465.

Nishat, A. 1993. *Freshwater Wetlands in Bangladesh: Status and Issues*. IUCN The World Conservation Union, Dhaka, Bangladesh., pp. 9-22.

Oksanen, J., F. G. Blanchet, M. Friendly, R. Kindt, P. Legendre, D. McGlinn, P. R. Minchin, R. B. O'Hara, G. L. Simpson P. Solymos, M. H. M. Stevens, E. Szoecs and H. Wagner. 2019. Vegan: Community Ecology Package. R package version 2.5-6

Onwuka, M. C., M. N. Rajpar and M. Zakaria. 2020. Food variety of lesser whistling duck in Malaysian Lakes. *Pertanika J. Sci. Technol*. **28**: 1329-1343.

Pal, A., S. Dey and U. S. Roy. 2012. Seasonal diversity and abundance of herpetofauna in and around an industrial city of West Bengal, India. *J. Appl. Sci. Environ.* **7**: 281-286.

Pringle, J. D. 1984. Efficiency estimates for various quadrat sizes used in benthic sampling. *Can. J. Fish. Aquat. Sci.* **41**: 1485-1489.

Rahman, A. K. A. 2005. *Freshwater Fishes of Bangladesh.* Zoological Society of Bangladesh, Department of Zoology, University of Dhaka, Bangladesh. 263 pp.

Rosin, Z. M., P. Skórka, T. Pärt, M. Żmihorski, A. Ekner-Grzyb, Z. Kwieciński and P. Tryjanowski. 2016. Villages and their old farmsteads are hot spots of bird diversity in agricultural landscapes. *J. Appl. Ecol.* **53**: 1363-1372.

Shannon, C. E. and W. Wiener 1949. *The Mathematical Theory*. University of Illinois press, Urbana. 117 pp.

Shome, A. R., M. M. Alam, M. F. Rabbe, T. Mia, S. Munira, U. H. Ilma and M. F. Jaman. 2022b. Ecology of avifauna in green spaces of a sub-tropical urban landscape: Community structure and habitat preference. *J. biodivers. conserv. bioresour. manag.* **8**(2): 37-50.

Shome, A. R., M. F. Jaman, M. F. Rabbe and M. M. Alam. 2021a. Bird diversity, composition and response during COVID-19 in an urban landscape, Jamalpur, Bangladesh. *Dhaka Univ. J. Biol. Sci.* **30**: 261-274.

Shome, A. R., M. F. Rabbe, M. M. Alam, S. F. Emon, M. M. Islam, R. S. Setu, N. Khan and M. F. Jaman. 2022a. Avifauna in an urban landscape of a lower Ganges district, Bangladesh: Community structure, seasonality, habitat preference and conservation issue. *Dhaka Univ. J. Biol. Sci.* **31**: 343-360.

Shome, A. R., M. M. Alam, M. F. Rabbe, M. M. Rahman and M. F. Jaman. 2021b. Ecology and diversity of wildlife of Dhaka University campus, Bangladesh. *Dhaka Univ. J. Biol. Sci.* **30**(3): 429-442.

Shome, A. R. and M. F. Jaman. 2021. Diversity and seasonal occurrence of vertebrate wildlife at a rural site of Bangladesh: Threats and conservation issue. *J. biodivers. conserv. bioresour. manag.* **7**(2): 61-74.

Simpson, E. H. 1949. Measurement of diversity. *Nature*. **163**: 688.

Stella, J., M. Hayden, J. Battles, H. Piegay, S. Dufour and A. K. Fremier. 2011. The role of abandoned channels as refugia for sustaining pioneer riparian forest ecosystems. *Ecosyst.* **14**: 776-790.

Swift, B. L., J. S. Larson and R. M. DeGraaf. 1984. Relationship of breeding bird density and diversity to habitat variables in forested wetlands. *Wilson Bull.* **96**: 48-59.

Whittaker, R. H. 1965. Dominance and diversity in land plant communities: Numerical relations of species express the importance of competition in community function and evolution. *Science*. **147**: 250-260.

Wilbard, A. N. and M. A. Samora. 2013. Bird species composition and diversity in habitats with different disturbance histories at Kilombero Wetland, Tanzania. *Open J. Ecol.* **3**: 481-488.

(Manuscript received on 03 September, 2023)