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Present status and diversity of avian fauna in Purbasthali bird sanctuary, West Bengal, India

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ABSTRACT

Birds play a crucial role in many food webs of aquatic ecosystem and the birds are known as good 'bio-indicators' as they are very sensitive to minor environmental changes. The present study was carried out in Purbasthali bird sanctuary of West Bengal (India) and its surroundings from January 2016 to December 2016 to explore the current status and diversity of avian fauna. The point count and line transect methods were implemented in bird counting. A total of 86 species of birds belonging to 31 families were recorded from the study area. Anatidae and Ardeidae were the dominant families with highest relative diversity. Residential status, IUCN Red list status and Relative abundance of bird species were also considered. Different diversity indices were also calculated. Purbasthali bird sanctuary supports a huge amount of bird diversity. So continuous monitoring of avian fauna and health condition of the ecosystem by local or state levels on taking integrated management programs will helpful to maintain a sustainable development of the habitat.

Key words: Avian fauna, Aquatic ecosystem, Diversity, Purbasthali bird sanctuary.

INTRODUCTION

Lakes are highly complex, land interactive, most productive and fertile ecosystems in the world, constituting a treasury of biodiversity (Gibbs, 1993). In India, the meandering nature of the holy river Ganga and its tributaries in its lower course in West Bengal have given rise a large number of floodplain wetlands, mostly open-type oxbow lakes (Ganesan and Khan, 2007). These ox-bow lakes provide habitats and breeding grounds for a huge number of resident and migratory birds. As India is one of the 12 mega-biodiversity countries, supports a considerable amount of avifaunal population. There is approximately 9702 bird species recorded throughout the world (Sibley and Monroe, 1990), out of which Indian subcontinent supports 1313 (over 13%) of them (Grimmett *et al.* 2011). Birds are very sensitive to environmental changes and are used as a "bio-indicator" (Koli, 2014); also, because of their high mobility, birds react very rapidly to changes in their habitats (Morrisson 1986; Fuller *et al.* 1995). But due to some adverse climatic conditions and various anthropogenic activities the global diversity of birds has been decreasing in recent years. According to Birdlife International (2015), 1375 avian species are considered to be threatened with extinction globally out of which 84 species are from Indian subcontinent.

Several studies on local and migratory water-bird population and the effects of bird aggregation on the physico-chemical conditions of lake water and vice versa have been conducted in the state West Bengal of India by many workers (Patra *et al.* 2010; Datta, 2011; Singha Roy *et al.* 2011 *and* 2012; Bhattacharya and Roy, 2013). A few research works have been carried out in Purbasthali bird sanctuary concerning the ecology, environmental threat and socioeconomic issues (Ganesan and Khan, 2007; Ganguly, 2015; Biswas Roy *et al.* 2016). But the information on community structure, diversity and abundance of indigenous and migratory birds of Purbasthali bird sanctuary is scarce. So the present study is an effort to explore the present status and diversity of avian fauna of this area.

MATERIALS AND METHODS

Study area: Purbasthali bird sanctuary of West Bengal is positioned on 23°27' N latitude and 88° 20' E longitude, at an elevation of 14 m. This open type ox-bow lake is situated in the Gangetic alluvial plain and covers an area approximately 20 sq. Km. It is a freshwater wetland and it belongs to Ramsar classification, the marshes, jheels, terai swamps and charland of the Gangetic plain class (Biswas Roy *et al.* 2016). The daily temperature of the study area varies from 16°C to 36°C and average rainfall is 150 mm. During post-monsoon season of each year a huge number of migratory water bird species aggregate in this wetland from different parts of the world and this phenomenon plays a crucial role for financial support of surrounding people.

Sampling sites: The bird species were collected from 3 sampling sites (Fig.1). The sampling sites were selected based on the following criteria – accessibility, distance

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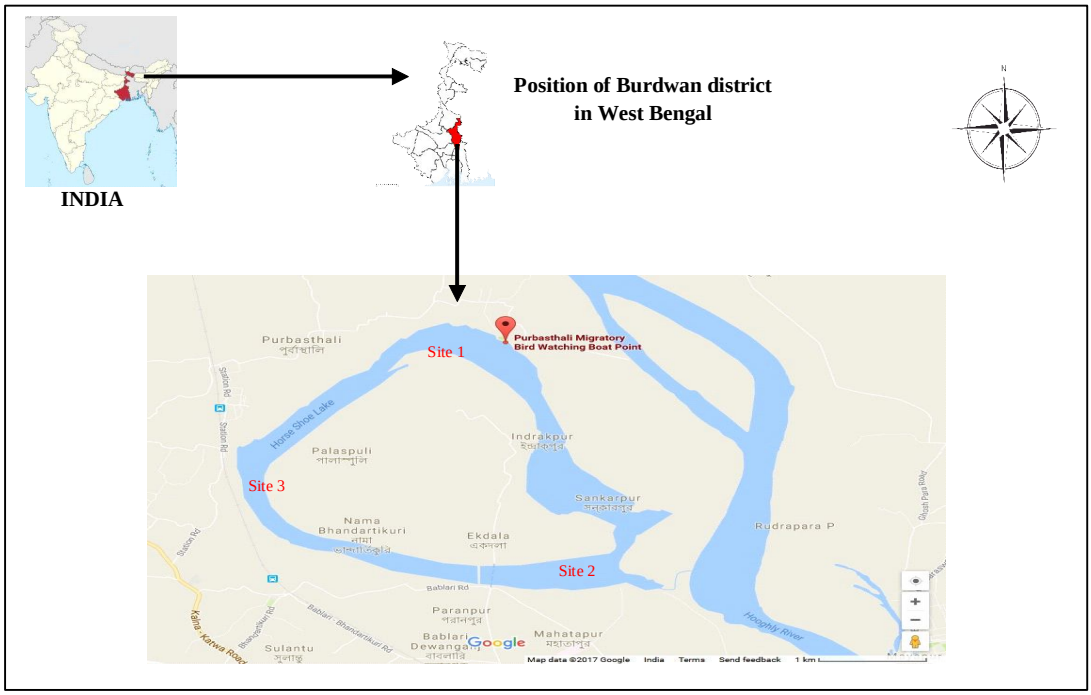

Fig. 1: Location map of Purbasthali bird sanctuary, West Bengal, India showing the sampling sites (*Source:* Google maps).

between the sampling points, variety of habitats and proximity to source of pollution such as sewage channels, bathing areas etc. the final map of study area and sampling sites were prepared through Geographic information system (GIS).

Data collection and identification: Monthly observations were carried out from January 2016 to December 2016. The various species of birds were counted with the help of two methods- Fixed radius (20 m) point count method for the forest areas, orchard; and Line transect method was applied to the open areas such as wetland and agricultural fields (Buckland *et al.* 1993; Sutherland *et al.* 2005). Observations were conducted with the help of Olympus 8-16×40 zoom DPS I Binocular and photography was carried out with Nikon D7000 DSLR camera and Nikon AF-S DX NIKKOR 55-300 mm f/4.5-5.6 G ED VR lens. Birds were censured 4 times in a month (Froneman *et al.* 2001; Urfi *et al.* 2005) and the mean values were taken into consideration.

Bird species were identified with the help of following literatures: Ali and Ripley (1987), Inskipp *et al.* (1996) and Grimmet *et al.* (1999). Some inconspicuous bird species were identified based on their calls (Aynalem and Bekele, 2008). IUCN status of the bird species were recognised as per IUCN (2016).

Data analysis: Residential status of different bird species like Resident (R), Resident-Migrant (RM) and Migrant (M) were given strictly on the basis of occurrence and sightings in the study area during study period (Singh and Laura, 2013).

Relative abundance was assessed on the basis of frequency of sightings as described by Khan (2005) and these were denoted as – 'Very common' (seen on 75–100% of visits), 'Common' (seen on 50–74% of visits), 'Uncommon' (seen on 25–49% of visits) and 'Rare' (seen on <25% of visits).

Relative diversity (RD) of bird families was calculated following the formula of Torre-Cuadros *et al.* 2007. The Shannon diversity index (H´), Simpson diversity index (D), Margallef diversity index (M) and Bray Curtis cluster analysis of bird population of 3 sampling sites were calculated with the help of Bio-Diversity Pro 2.0 Professional software programme. The cluster analysis was used to prepare a dendrogram to show the similarity in bird families on 3 sampling sites of the study area.

RESULTS AND DISCUSSION

Bird diversity: From the present study it is revealed that a total of 86 species of birds belonging to 31 families were recorded during the study period from Purbasthali bird sanctuary and its surroundings (Table 1). Anatidae and Ardeidae are found to be the most dominant families in the study area with 7 species each, followed by Scolopacidae (6 species), Motacillidae, Picidae (5 species each), Alcedinidae, Charadriidae, Cuculidae, Rallidae (4 species each), Accipitridae, Columbidae, Estrildidae, Megalaimidae, Sturnidae (3 species each), Ciconiidae, Dicruridae, Jacanidae, Laniidae, Nectariniidae, Phalacrocoracidae, Pycnonotidae, Strigidae (2 species each), Aegithinidae,

Table 1: List and status of total avifauna seen in Purbasthali bird sanctuary during study period.

Family	Scientific name	Common Name	Residential status	IUCN status	Relative abundance
Accipitridae	*Milvus migrans*	Black Kite	R	LC	C
Accipitridae	*Accipiter badius*	Shikra	R	LC	UC
Accipitridae	*Gyps bengalensis*	white-rumped vulture	R	CR	RA
Aegithinidae	*Aegithina tiphia*	Common Iora	RM	LC	UC
Alcedinidae	*Alcedo atthis*	Common Kingfisher	R	LC	C
Alcedinidae	*Halcyon smyrnensis*	White Throated Kingfisher	R	LC	VC
Alcedinidae	*Ceryle rudis*	Pied kingfisher	R	LC	C
Alcedinidae	*Pelargopsis capensis*	Stork Billed Kingfisher	R	LC	UC
Anatidae	*Dendrocygna javanica*	Lesser Whistling Duck	M	LC	VC
Anatidae	*Anas crecca*	Common Teal	M	LC	RA
Anatidae	*Anas acuta*	Northern Pintail	M	LC	RA
Anatidae	*Anas platyrhynchos*	Mallard	M	LC	RA
Anatidae	*Anas strepera*	Gadwall	M	LC	RA
Anatidae	*Tadorna ferruginea*	Ruddy Shelduck	M	LC	UC
Anatidae	*Netta rufina*	Red Crested Pochard	M	LC	UC
Ardeidae	*Egretta garzetta*	Little Egret	R	LC	VC
Ardeidae	*Ardea intermedia*	Intermediate Egret	R	LC	C
Ardeidae	*Ardea alba*	Great Egret	RM	LC	UC
Ardeidae	*Bubulcus ibis*	Cattle Egret	R	LC	VC
Ardeidae	*Ardeola grayii*	Indian Pond Heron	R	LC	C
Ardeidae	*Nycticorax nycticorax*	Black Crowned Night Heron	R	LC	RA
Ardeidae	*Ardea purpurea*	Purple Heron	RM	LC	RA
Charadriidae	*Vanellus indicus*	Red Wattled Lapwing	RM	LC	C
Charadriidae	*Vanellus cinereus*	Grey Headed Lapwing	RM	LC	UC
Charadriidae	*Charadrius leschenaultii*	Greater Sand Plover	M	LC	RA
Charadriidae	*Charadrius mongolus*	Lesser Sand Plover	M	LC	RA
Ciconiidae	*Anastomus oscitans*	Asian Open Bill Stork	RM	LC	VC
Ciconiidae	*Leptoptilos javanicus*	Lesser Adjutant stork	RM	VU	RA
Cisticolidae	*Orthotomus sutorius*	Common Tailor Bird	R	LC	C
Columbidae	*Spilopelia chinensis*	Spotted Dove	R	LC	C
Columbidae	*Chalcophaps indica*	Emerald Dove	R	LC	RA
Columbidae	*Treron phoenicoptera*	Yellow Footed Green pigeon	R	LC	RA
Cuculidae	*Cuculus micropterus*	Indian Cuckoo	R	LC	C
Cuculidae	*Hierococcyx varius*	Common Hawk Cuckoo	R	LC	UC
Cuculidae	*Eudynamys scolopaceus*	Asian Koel	R	LC	C
Cuculidae	*Centropus sinensis*	Greater Coucal	R	LC	VC
Dicruridae	*Dicrurus macrocercus*	Black Drongo	R	LC	VC
Dicruridae	*Dicrurus aeneus*	Bronzed Drongo	RM	LC	RA
Estrildidae	*Lonchura malabarica*	Indian SilverBill	R	LC	RA
Estrildidae	*Lonchura punctulata*	Scaly Breasted Munia	R	LC	RA
Estrildidae	*Lonchura malacca*	Black Headed Munia	R	LC	UC
Jacanidae	*Metopidius indicus*	Bronze Winged Jacana	R	LC	C
Jacanidae	*Hydrophasianus chirurgus*	Pheasant Tailed Jacana	R	LC	VC
Laniidae	*Lanius cristatus*	Brown shrike	M	LC	C
Laniidae	*Lanius schach*	Long Tailed Shrike	RM	LC	UC
Megalaimidae	*Megalaima haemacephala*	Coppersmith Barbet	R	LC	RA
Megalaimidae	*Megalaima lineata*	Lineated Barbet	R	LC	UC
Megalaimidae	*Megalaima asiatica*	Blue Throated Barbet	R	LC	C
Meropidae	*Merops orientalis*	Green Bee-Eater	R	LC	C
Motacillidae	*Motacilla flava*	Yellow Wagtail	M	LC	UC
Motacillidae	*Motacilla cinerea*	Grey Wagtail	M	LC	RA
Motacillidae	*Motacilla alba*	White Wagtail	RM	LC	C
Motacillidae	*Motacilla maderaspatensis*	White Browed Wagtail	R	LC	UC
Motacillidae	*Anthus rufulus*	Paddy Field Pipit	R	LC	C
Nectariniidae	*Nectarinia asiatica*	Purple Sunbird	R	LC	RA

Table.1 continue.....

Table.1 continue.....

Nectariniidae	*Nectarinia zeylonica*	Purple Rumped Sunbird	R	LC	UC
Pandionidae	*Pandion haliaetus*	Osprey	M	LC	RA
Phalacrocoracidae	*Phalacrocorax niger*	Little Cormorant	R	LC	VC
Phalacrocoracidae	*Phalacrocorax carbo*	Great Cormorant	RM	LC	RA
Picidae	*Dinopium benghalense*	Black Rumped Flameback	R	LC	C
Picidae	*Chrysocolaptes lucidus*	Greater Flameback	R	LC	UC
Picidae	*Dendrocopos macei*	Fulvous Breasted Woodpecker	R	LC	RA
Picidae	*Celeus brachyurus*	Rufous Woodpecker	R	LC	RA
Picidae	*Dinopium javanense*	Common Flameback	R	LC	C
Podicipedidae	*Podiceps ruficollis*	Little Grebe	M	LC	VC
Psittaculidae	*Psittacula krameri*	Rose ringed Parakeet	R	LC	C
Pycnonotidae	*Pycnonotus cafer*	Red-Vented Bulbul	R	LC	VC
Pycnonotidae	*Pycnonotus jocosus*	Red-Whiskered Bulbul	R	LC	C
Rallidae	*Fulica atra*	Common Coot	RM	LC	UC
Rallidae	*Gallinula chloropus*	Common Moorhen	RM	LC	C
Rallidae	*Porphyrio porphyrio*	Purple Swamp-hen	M	LC	C
Rallidae	*Amaurornis phoenicurus*	White Breasted Water-hen	R	LC	C
Recurvirostridae	*Himantopus himantopus*	Black Winged Stilt	M	LC	RA
Rhipiduridae	*Rhipidura albicollis*	White Throated Fantail	R	LC	UC
Scolopacidae	*Limosa limosa*	Black Tailed Godwit	M	NT	RA
Scolopacidae	*Tringa glareola*	Wood Sandpiper	M	LC	RA
Scolopacidae	*Tringa totanus*	Common redshank	M	LC	UC
Scolopacidae	*Tringa hypoleucos*	Common Sandpiper	RM	LC	C
Scolopacidae	*Gallinago gallinago*	Common Snipe	M	LC	C
Scolopacidae	*Tringa nebularia*	Common Greenshank	M	LC	UC
Strigidae	*Bubo zeylonensis*	Brown Fish Owl	R	LC	RA
Strigidae	*Ketupa ketupu*	Buffy Fish Owl	R	LC	RA
Sturnidae	*Acridotheres tristis*	Common Myna	R	LC	VC
Sturnidae	*Acridotheres fuscus*	Jungle Myna	R	LC	VC
Sturnidae	*Acridotheres ginginianus*	Bank Myna	R	LC	C
Zosteropidae	*Zosterops palpebrosus*	Oriental White Eye	R	LC	RA

C: Common; CR: Critically endangered; LC: Least concern; M: Migrant; NT: Near threatened; R: Resident; RA: Rare; RM: Resident-Migrant; Sl. no.: Serial number; UC: Uncommon; V: Vulnerable; VC: Very common.

Cisticolidae, Meropidae, Pandionidae, Podicipedidae, Psittaculidae, Recurvirostridae, Rhipiduridae and Zosteropidae (single species each) (Table 1). Roy *et al.* (2016) have also observed that Anatidae and Ardeidae were the dominant families in Purbasthali bird sanctuary.

The residential status of bird species found in study area is tabulated in the Table 1. Out of 86 bird species, 51 were resident, 14 species were resident-migrant (undergo local migration) and rest 21 species were migratory. The winter migrants are not only coming from different states of India like Jammu and Kashmir, Arunachal Pradesh, but also from different countries like Siberia, Tibet and different range of Himalayas (Roy *et al.* 2016). The winter migrants like *Anas crecca, Anas acuta, Anas strepera, Netta rufina, Charadrius leschenaultia, Gallinago gallinago* etc. appeared in the study area from November and stayed till middle of March of a calendar year. The population of migratory birds reached its peak value during December and January. The basic requirements of the migratory birds at their wintering ground are availability of adequate food and safety (Basavarajappa, 2006), which were present in Purbasthali bird sanctuary with its adequate space, vast breeding ground, different niches for diverse species, vast agricultural fields and adjacent forest areas.

Out of 86 species recorded, 13 were categorised as 'very common' species such as *Halcyon smyrnensis, Dendrocygna javanica, Bubulcus ibis, Pycnonotus cafer* etc. *Halcyon smyrnensis* is considered as state bird of West Bengal. 26 species were considered as 'common', 19 species as 'uncommon' and rest 28 species were designated as 'rare' (Table 1).

Analysis of Relative diversity (RD) of bird families showed that Anatidae and Ardeidae have the highest RD value (8.140), whereas Aegithinidae, Cisticolidae, Meropidae, Pandionidae, Podicipedidae, Psittaculidae, Recurvirostridae, Rhipiduridae and Zosteropidae have the lowest RD value (1.163). The RD values of different bird families were shown in the Fig. 2.

Total avian species recorded from the study area were categorized under different threatened categories by IUCN (Version 2016-3). Only one species (*Leptoptilos javanicus*) have been enlisted as Vulnerable (V). *Gyps bengalensis* was placed in Critically endangered (CR)

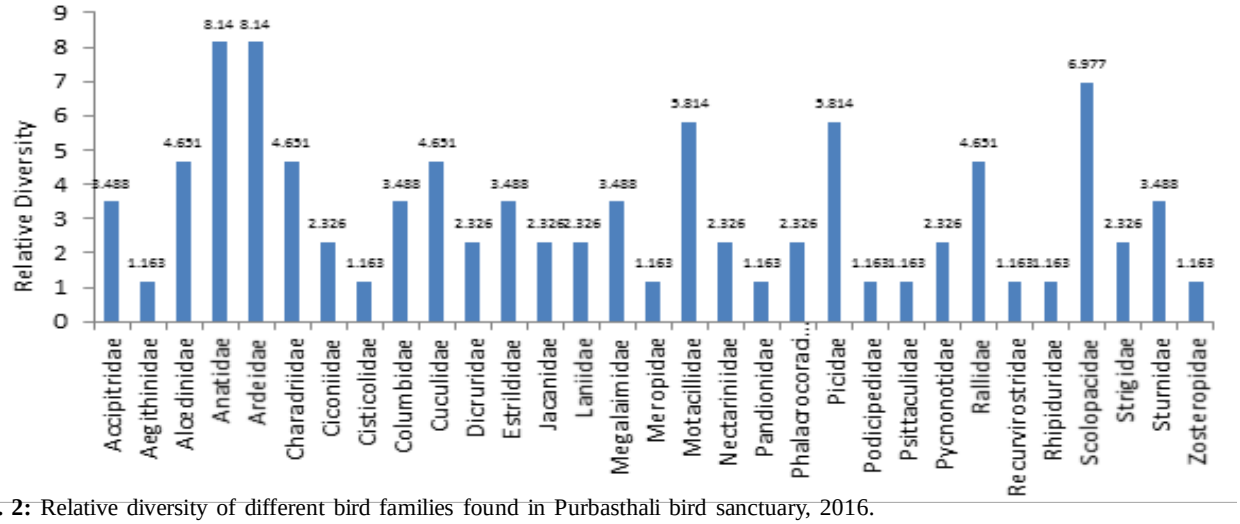

Fig. 2: Relative diversity of different bird families found in Purbasthali bird sanctuary, 2016.

Table 2: The Shannon, Simpson and Margalef diversity index of bird community in different months of the year 2016 in Purbasthali bird sanctuary.

Months	H'	H_{max}	J'	D	M
January	1.471	1.751	0.857	0.053	30.103
February	1.487	1.749	0.851	0.049	30.67
March	1.476	1.694	0.871	0.046	31.269
April	1.323	1.552	0.853	0.069	30.047
May	1.272	1.495	0.852	0.077	25.534
June	1.289	1.547	0.832	0.083	26.056
July	1.311	1.486	0.882	0.063	27.127
August	1.333	1.515	0.881	0.059	27.383
September	1.301	1.481	0.878	0.066	27.583
October	1.394	1.591	0.874	0.06	33.393
November	1.426	1.727	0.826	0.063	32.248
December	1.473	1.776	0.828	0.058	30.549

H': Shannon H' Log base 10; H_{max}: Shannon H_{max} Log base 10; J': Shannon J'; D: Simpson diversity index; M: Margalef M Base 10.

category and *Limosa limosa* was positioned in Near threatened (NT) category. Rest of the species (83 species) were listed as Least concerned (LC) (Table 1).

Diversity index: Different bird diversity indices calculated from Purbasthali bird sanctuary during study period are tabulated in the Table 2. In the present study the H´ ranged from 1.272 to 1.487. According to Derso *et al.* (2015), most values calculated using the H´ range from 1.5 to 3.5, rarely exceeding 4.5; Values above 3.0 indicate that habitat structure is very much balanced and stable, whereas values below 1.0 indicate the presence of pollution and degradation of habitat structure. Based on these principles, it was observed that none of the sampling sites of the study area lowered the level

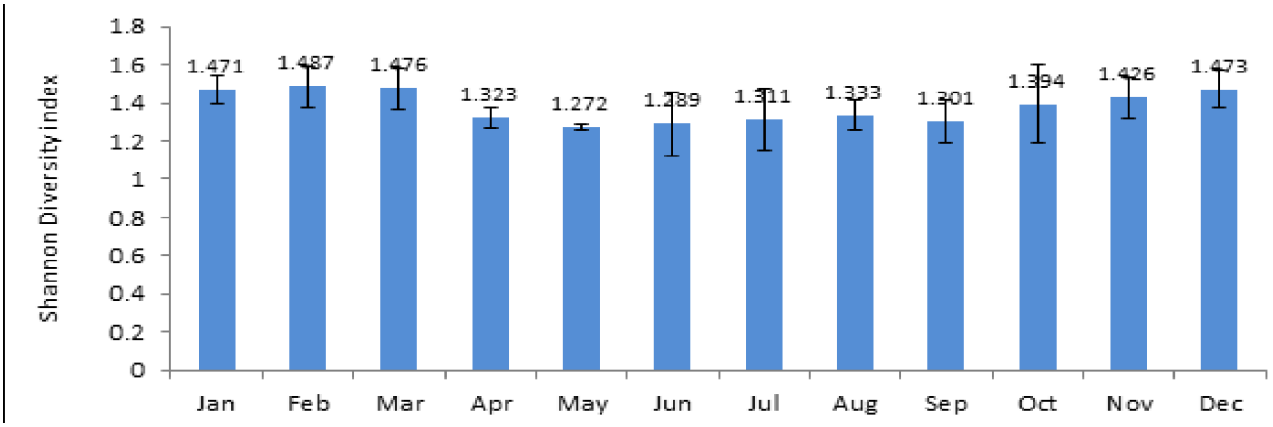

Fig. 3: Average Shannon diversity index calculated from birds in Purbasthali bird sanctuary, West Bengal, India, 2016.

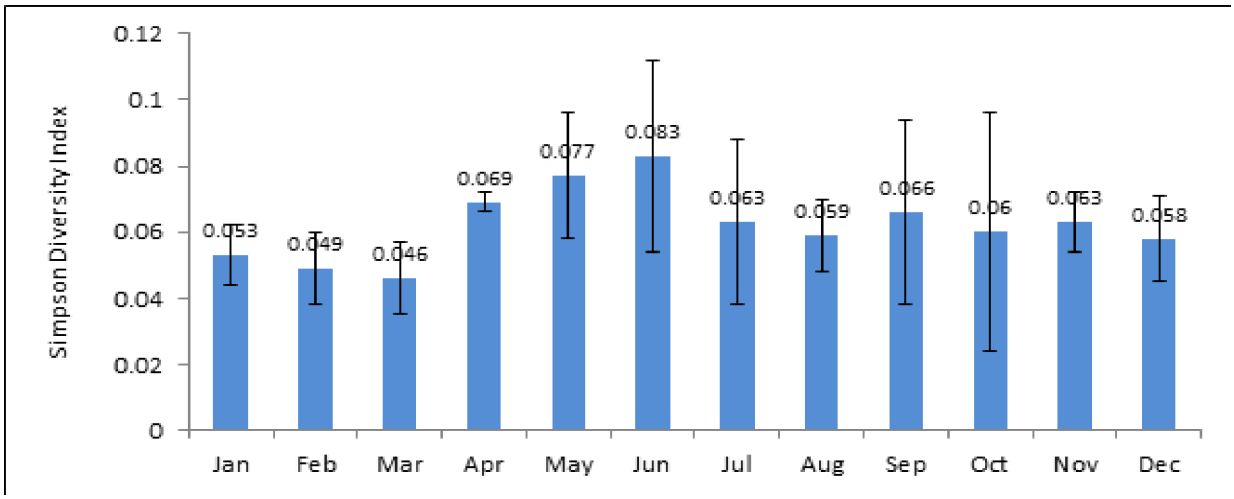

Fig. 4: Average Simpson diversity index calculated from birds in Purbasthali bird sanctuary, West Bengal, India, 2016.

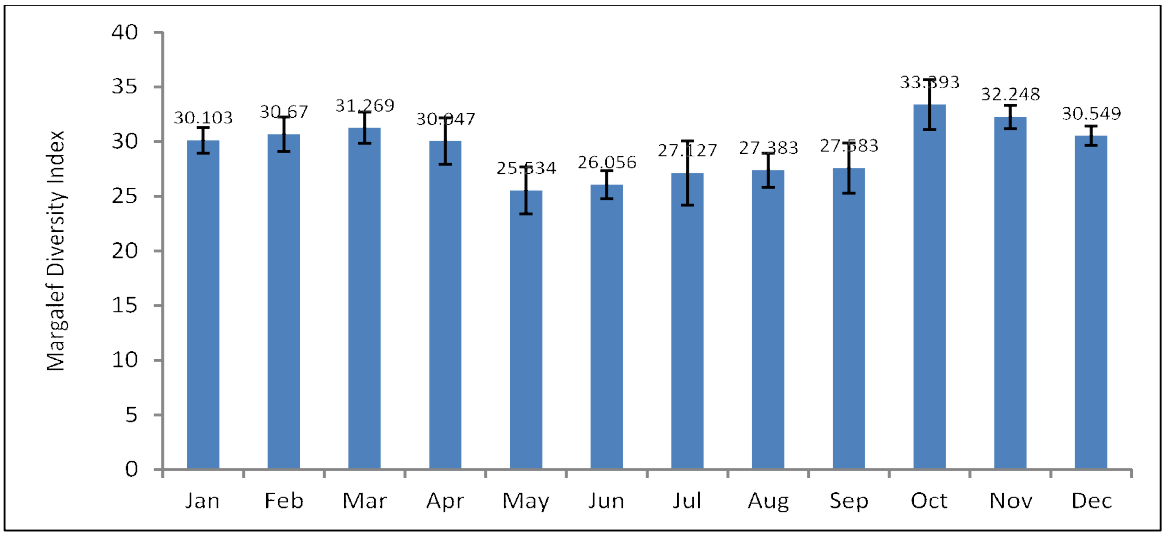

Fig. 5: Average Margalef diversity index calculated from birds in Purbasthali bird sanctuary, West Bengal, India, 2016.

of 1.0 in case of H´ (Fig. 3). D, calculated from the study area with its lowest value as 0.046 and highest value as 0.083 (Fig. 4). According to Smith and Wilson (1996), D values should be between zero and one. Zero represents minimum evenness and one for the maximum. So the D values of the present study correlate with the aforesaid standards. The values of M of bird were between 25.534 and 33.393 (Fig. 5). The lowest value was observed in the month of May whereas the highest value was seen in the month of October during the study period. The reason for such type of differences in species richness and diversity indices might be due to different anthropogenic activities (Singh and Laura, 2013). Bird species richness has negative relationship with urbanization (Mckinney, 2002).

The much higher values of H´ were observed from the study period during the post-monsoon months. It may be due the aggregation of large variety of migratory water bird species into the lake for food and forage. Whereas lesser values of H´ were found during pre-monsoon months. This may be due to high temperature, scarcity of nutrients, shelter and migration of local migrant species to nearby agricultural fields for food (Maheswaran *et al.* 2001).

The dendrogram shows the similarity in the number of avian species between the three sampling sites of the sanctuary (Fig. 6). High similarity in bird species was found between Site-2 and Site-3, followed by Site-1 and Site-2 and Site-1 and Site-3. High amount of species diversity and richness was observed in Site-1 compared to Site-2 and Site-3. Same type of anthropogenic disturbances such as bathing, washing, pisiculture, irrigation, water herbs cultivation, recreational activities (Roy *et al.* 2016) were observed in Site-2 and Site-3. It may be the reason of such similarity between these two sites. So the result of the present study revealed that higher species diversity in Site-1 was seen due to less pollution, and less human interference than the other 2 sites (Site-2 and Site-3).

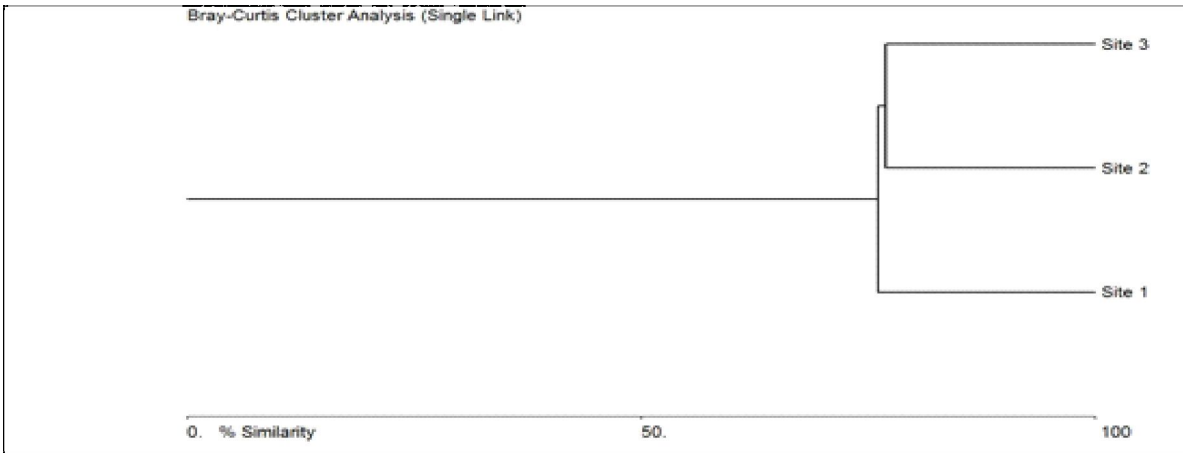

Fig. 6: Dendrogram showing the similarity in number of bird families on three sampling sites of Purbasthali bird sanctuary, 2016.

CONCLUSION

From the above study it can be concluded that Purbasthali bird sanctuary not only supports a huge amount of bird diversity but also plays an important role in providing different types of ecosystem services to the local people. The huge avian diversity and richness of this area was probably due to the complex vegetation structure which provides shelter, varied niches, microhabitats and suitable foraging grounds to the different types of water and land birds. Despite of its importance, the lake ecosystems in our country are susceptible from different anthropogenic activities. These play a negative impact on aggregation and diversity of avian population. So the human interferences should be reduced to conserve the species richness and abundance. Moreover, continuous monitoring of avian fauna and health condition of the ecosystem by local or state levels on taking integrated management programs will be helpful to maintain a sustainable development of the habitat.

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REFERENCES

Ali, S., Ripley, S.D. (1987). Handbook of the Birds of India and Pakistan. *Oxford University Press*. New Delhi.

Aynalem, S., Bekele, A. (2008). Species composition, relative abundance and distribution of bird fauna of riverine and wetland habitats of Infranz and Yiganda at southern tip of Lake Tana, Ethiopia. *Trop Ecol*., **49**:199–209.

Basavarajappa, S. (2006). Avifauna of Agro ecosystem of Maidan area of Karnataka. *Zoo's Print*. **21**(4):2217-2219.

Bhattacharya, R., Roy, R. (2013). Habitat wise distribution of local birds in the vicinity of Krishnanagar. *Proc. Nat. Con. Cha. Bio. Res. Man*. ISBN 978-81-927762-0-0. pp- 179-187.

Bird Life International. IUCN Red List for birds (2015). http://www.birdlife.org/2015. Accessed on 06 June, 2016.

Biswas Roy, M., Chatterjee, D., Mukherjee, T., Roy, P.K. (2016). Environmental threat to wetland bio-diversity on migratory bird: a case study of peri-urban area of West Bengal. *Asian Journal of Current Research*, **1**(1): 30-38, 2016.

Buckland, S.T., Anderson, D.R., Burnham, K.P., Laake, J.L. (1993). Distance Sampling: Estimating the Abundance of Biological Populations. Chapman and Hall, New York

Das, S. (2012). Utilization and management of wetland resources of West Bengal, India. Ph.D thesis, Indian Institute of Technology-Kharagpur.

Datta, T. (2011). Human interference and avifaunal diversity of two wetlands of Jalpaig-uri, West Bengal, India. *Journal of Threatened Taxa* **3** (12): 2253–2262.

Derso, S., Beyene, A., Getachew, M., Ambelu, A. (2015). Assessment of ecological quality of hot springs in the Eastern Amhara Region. *Environ Syst Res* (2015) **4**:19.

Froneman, A., Mangnall, M.J., Little, R.M., Crowe, T.M. (2001). Water bird assemblages and associated habitat characteristics of farm ponds in the Western Cape, South Africa. *Biodiversity and Conservation*, **10**:251-271.

Fuller, R.J., Gough, S.J., Marchant, J.H. (1995). Bird populations in new Lowland woods: Landscape, Design and management perspectives. *In: The Ecology of Woodland Creation, (Ferris-Kaan, R., ed.)* pp. 163-182. London: John Wiley and *and* Sons Ltd.

Ganesan, L., Khan, R.A. (2007). Studies on ecology of Zooplankton in a Floodplain Wetland of West Bengal, India, *Proceedings of Taal 2007*: The 12th World lake conference: 67-73.

Ganguly, S. (2015). Diversity and temporal variation of migratory water birds of some selected wetlands from eastern India. *Species*,**13**, 42-50.

Gibbs, J.P. (1993). The importance of small wetlands for the persistence of local populations of wetland associated animals. *Wetlands*, **13**:25-31.

Grimmett, R., Inskipp, C., Inskipp, T. (1999). Pocket guide to the birds of the Indian subcontinent. Oxford University Press, New Delhi, India.

Grimmett, R., Inskipp, C., Inskipp, T. (2011). Birds of the Indian Subcontinent. India: Oxford.

Inskipp, T., Lindsey, N., Duckworth, W. (1996). An annotated checklist of the birds of the Oriental region. Sandy, Bedfordshire, United Kingdom: Oriental Bird Club.

IUCN (2016). The IUCN Red list of threatened species. Version 2016-3. http://www.iucnredlist.org.

Khan, M.M.H. (2005). Species diversity, relative abundance and habitat use of the birds in the Sundarbans East Wildlife Sanctuary, Bangladesh. *FORKTAIL* **21** (2005): 79–86.

Koli, V.K. (2014). Diversity and status of avifauna in Todgarh-Raoli Wildlife Sanctuary, Rajasthan, *India Journal of Asia-Pacific Biodiversity*, **7** (2014) 401-407.

Maheswaran, G., Rahmani, A.R. (2001). Effects of water level changes and wading bird abundance on the foraging behavior of blacknecked stork, Ephippiorhynchus asiaticus in Dudwa National Park, *India. Journal Bioscience*, **26**:373-382.

Mckinney, M.L. (2002). Urbanization, biodiversity, Conservation. *Bioscience*, **52**:883-890.

Morrisson, M.L. (1986). Bird populations as indicators of environmental changes. *Current Ornithology*, **3**: 429-451.

Patra, A., Santra, K.B., Manna, C.K. (2010). Limnological studies related to physico-chemical characteristics of water of santragachi and joypur jheel, West Bengal, India, *Our nature* **8**:185-203

Roy, M.B., Chatterjee, D., Mukherjee, T., Roy, P.K. (2016). Environmental threat to wetland bio-diversity on migratory bird: a case study of peri-urban area of West Bengal. *Asian Journal of Current Research*. **1**(1): 30-38.

Sibley, C.G., Monroe, B.L. (1990). Distribution and taxonomy of birds of the world. New Haven, CT: Yale University Press.

Singh, A., Laura, J.S. (2013). Avifauna Species Diversity and their Abundance in Tilyar Lake, Rohtak, Haryana (India). *Bull. Env. Pharmacol. Life Sci.*, **3** (1) December 2013: 180-185.

Singha Roy, U., Banerjee, P., Mukhopadhyay, S.K. (2012). Study on avifaunal diversity from three different regions of North Bengal, India. *Asian Journal of Conservation Biology*, ISSN 2278-7666. December 2012. Vol. **1** No. 2, pp. 120 -129.

Singha Roy, U., Roy Goswami, A., Aich, A., Mukhopadhyay, S.K. (2011). Changes in densities of waterbird Species in Santragachi Lake, India: Potential Effects on Limnochemical Variables . *Zoological Studies* **50**(1): 76-84.

Smith, B., Wilson, J.B. (1996). A consumer's guide to evenness indices. Oikos **76**:70–82.

Sutherland, W.J., Newton, I., Green, R.E. (2005). Bird Ecology and Conservation, a Handbook of techniques. New York: Oxford University Press.

Torre-Cuadros, MDLAL., Herrando-Perez, S., 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 and Conservation*, **16**:2965-2988.

Urfi, A.J., Monalisa, S., Kalam, A., Meganathan, T. (2005). Counting birds in India: Methodologies and trends. *Current Science*, **89**:1997-2003.