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Effect of habitat multifariousness on aquatic avian diverseness in Tighra fresh water reservoir Gwalior (M.P.) India

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Abstract
The present study has been done to understand fully the significance of local and regional landscapes for bird conservation, it is necessary to comprehensively understand the diversity and structure of the birds' populations. Birds are the pivotal biological indicators used to assess the health of ecosystems and environments. This study aims to explore the connections between avian diversity, richness, composition, and the characteristics of habitats within the Tighra fresh water Reservoir. In this comprehensive research, Aquatic avifaunal diversity of Tighra Reservoir has been Observed to know the present status of this reservoir during February 2022 to January 2023. Four sampling stations have been selected for the observation of current status of birds depicted as Main tourist place of reservoir (Near Tighra Village) S1, (Malipura village) S2, (Mircha village) S3, (Nalkeshwar) S4. Visual encounter surveys were by using the line transect and point count methods, picture was also taken for identification of birds. Total 66 Species of aquatic birds were observed belonging to 18 families 11 orders.

Keywords: Aquatic avifauna, diversity, habitat, Tighra reservoir, ecology

Introduction

Birdlife is regarded as the most vital element of any ecosystem, playing a important role in maintaining ecological balance (Saini, 1994) [22]. Ecologically, birds serve major functions as scavenger's, seed dispersers, predators, and pollinators (Ali, 2013) [1]. Avian diversity, a critical indicator of ecosystem health, is influenced by various environmental factors, among which habitat multifariousness—or the variety and complexity of habitats—plays a significant role.

Habitat multifariousness show the heterogeneity within an ecosystem, encompassing variation in vegetation structure, micro habitats and availability of resources (Mac Arthur and MacArthur, 1961) [14, 15]. To Understanding the relationship between avian diverseness and habitat multifariousness is important for biodiversity conservation and ecosystem management.

In rooted ecological theory higher species diversity supports by the concept that diverseness of habitats. Wide range of niches provide more heterogeneous habitats and more species to coexist by reducing direct or indirect competition for resources (Tews *et al*., 2004) [20, 21]. Relationship has been explore among various ecosystem from temperate to tropical rainforests, suggesting that the structural complication and variety of resources are key features of species richness and its abundance (Benton, Vickery, & Wilson, 2003) [2].

Bird diversity is correlated with vegetation stratification and the presence of variety of plant species has demonstrated while research in tropical forests, feeding and nesting opportunities also offered (Karr and Roth 1971) [9, 10].

In comparison with monoculture a higher diversity of bird species supports by heterogeneous habitats such as hedgerows and mixed crops field, In agricultural landscape (Benton *et al*., 2003) [2].

Relationship between habitat multifariousness and avian diverseness can varied among regional and ecological context, geographical location, human - induced habitat alterations and climatic factors can supports this relationship.

Diversity of Aquatic birds serve as the both qualitative and quantitative indicator for observing different habitat types and it plays a significance role in maintaining the ecological balance within the agro-ecosystem balance with the agro-chemical (Haslem and Bennett, 2008) [7].

To Understanding biodiversity and ecosystem health it is pivotal to ecological study of avian fauna. Birds are the key indicator of environmental change due to their sensitivity to climatic variations and habitat alterations, for ecological subjects making them essential (Johnston *et al*.,2020) [8].

There are 11,162 bird's species recorded Globally, with India hosting 1,369 of them, which contribute almost 15% of the world, s avian fauna, Highest status of biodiversity-rich region in India highlighting. In India among the bird species 3 are breeding endemics, 83 are endemic and 105 are threatened globally (Bird Life International, 2022) [5].

Various factors shaped Bird, s diversity, including climatic conditions, habitat heterogeneity and resources availability. To sustaining avian diversity Habitat heterogeneity, diversity and complexity of habitats, play a critical role. Numerous niches and resources provide diverse habitat, allowing maximum number of birds species to coexist by minimizing competition (Birkhofer *et al*., 2020) [4]. Studies have shown that structurally complex environments, such as tropical rainforests and varied agricultural landscapes, support higher avian diversity compared to monoculture or simplified landscape (Tews *et al*., 2004: Fahrig et el.,2022) [6, 20, 21]

Material and Method

Sampling Procedure

Birds were observed during summer, winter, rainy seasons at the most active periods for birds, early morning from 6:30 to 10:00 am and evening from 4:00 to 6:00 pm, from July 2021 to June 2023. The study area was surveyed for

avifauna using the line transect method (Sale and Berkmuller, 1988) and point transect method (Verner, 1985). Birds were observed with Nikon Action 8X40 binoculars at various stations while walking straight the boundaries of the selected sampling stations. Pictures were clicked as needed to accurately recognized birds to the genus and species levels using a camera Canon D-60. The birds were identified and classified based on standard field guides by Ali (2006) and Grimmett. (2001).

Study area

The Tighra Reservoir considered the lifeline of Gwalior, was primarily constructed to supply water to the city. Located approximately 23 km west of Gwalior, The Tighra Dam forms a large water reservoir on the Saank River, near Tighra village in Gwalior district, Madhya Pradesh. Established in 1917, the reservoir is a perennial water source situated between longitudes 78°01'30" E and 77°57'54" E and latitudes 26◦11'42" N and 26◦14'08"N, at an altitude of 218.58 meters above mean sea level. The catchment area of the reservoir spans 412.25 square kilometers, with a maximum depth of 24 meters and a length of 1,341 meters. It has a capacity of 4.8 million cubic meters and can discharge up to 1,274 cubic meters per second. Surrounded by hills on three sides, the northern and western hills rise to 300 meters, while the southern and southeastern hills reach about 225 meters. The Saank River joins the reservoir through a gorge on the southwestern side, and approximately a dozen small streams flow into the reservoir from the surrounding hill slopes. To the northeast of the reservoir, there is a concrete masonry wall.

Table 1: Showing the sampling site

S.No.	Sampling Site	Co-ordinates
1.	Tighra Dam near Tighra Village	26◦12'56.85"N, 78◦00'31.61"E
2.	Malipura village	26◦12'14.05"N, 78◦00'13.80"E
3.	Mircha village	26◦11'18.83"N, 77◦56'46.94"E
4.	Nalkeshwar	26◦13'32.35"N, 77◦57'54.17"E

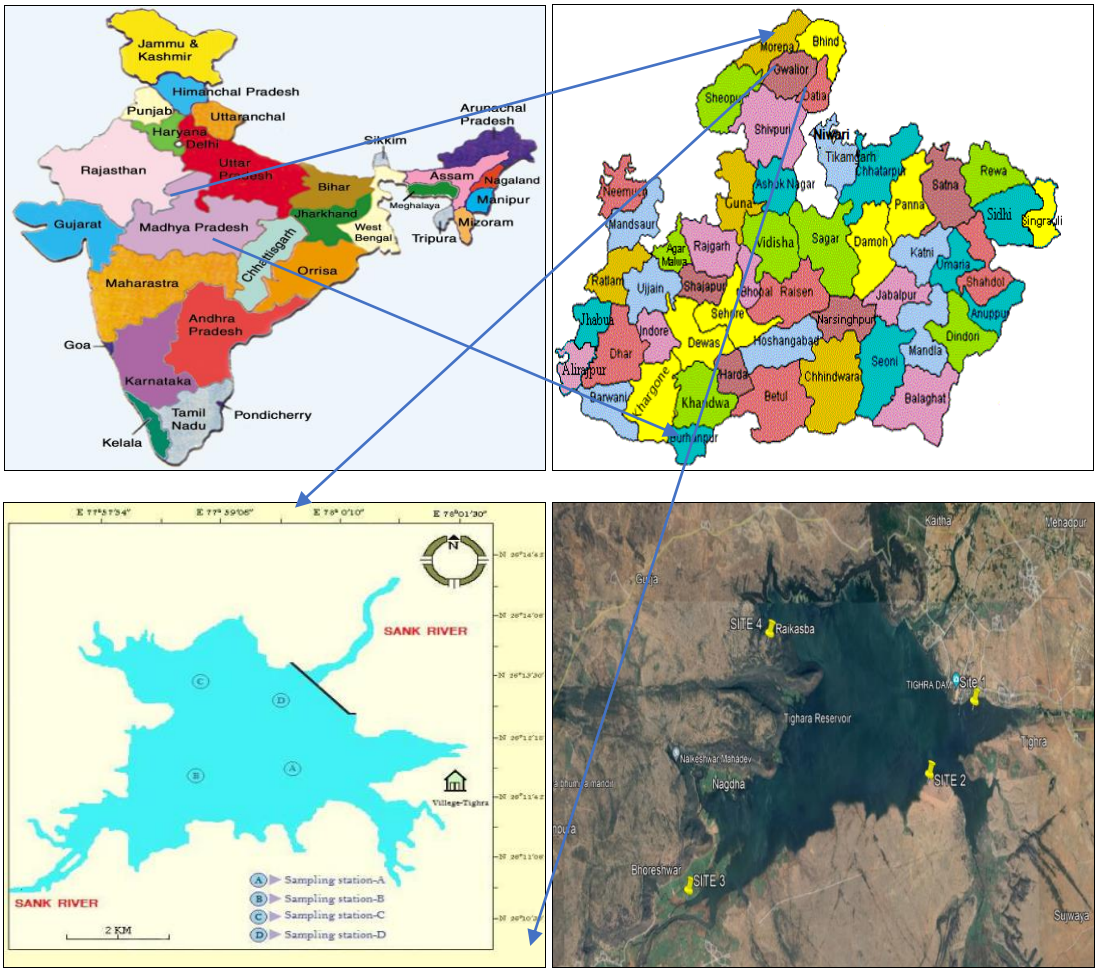

Fig 1: Sketch of Tighra reservoir, Gwalior

Fig 2: Satellite image of Tighra reservoir (www. google.com)

Data analysis

Species diversity

The Renyi diversity profile approach was used to calculate the species diversity of the studied for reservoir birds' study or land use types, utilizing the vegan 2.5-7 package (Oksanen *et al*., 2020) [18]. The Renyi diversity profile values (Hα) were derived from the average abundance values over two years, using a scaling parameter (α) ranging from zero to infinity (Legendre & Legendre, 1998; Kindt & Coe, 2005) [11, 13], according to the following formula:

$$H\alpha = 1\frac{1}{1-\alpha} ln \sum_{i=1}^{s} Pi\alpha$$

In this context, *pi* represents the average abundance of each bird species and α is the scaling parameter (Legendre &

Legendre, 1998; Kindt & Coe, 2005; Oksanen *et al*., 2020) [11, 13, 18].

The values of the Renyi profile at scales of 0, 1, 2, and infinity (∞) correspond to species richness, the Shannon diversity index, the Simpson diversity index, and the Berger-Parker diversity index, respectively (Legendre & Legendre, 1998; Kindt & Coe, 2005 [11]; Ahmad *et al*., 2019) [13].

Species richness

Sample (i.e., individual) and coverage-based rarefaction and extrapolation curves were generated using abundance data with the iNext 2.0.20 R package (Hsieh *et al*., 2016; Chao and Jost, 2012). To determine species richness differed significantly between the studied vegetation or land use types, the richness data was first subjected to the Levene's, s test for homogeneity of variance and the Shapiro–Wilk test for normality of distribution. Tukey Honest significant Difference (Tukey HSD) applied for the test of the multiple pairwise comparison between the means of studied aquatic avian diversity or reservoir use types for the identification of station shows the significant differences in species richness.

Species Composition

The Aquatic bird data collected over the period of three year from each sampling station to create a species-site matrix. To studied the differences in aquatic bird species composition between the studies vegetation or reservoir use types, By using the Bray - Curtis dissimilarity metric with vegan 2.5-7 package a non - metric multidimensional scaling (NMDS) was performed. The associated stress value was calculated to evaluate the NMDS, s efficiency. NMDS graph were plotted, where each ellipse (with its associated centroid) represents a specific vegetation or land use type. The distance between any two centroids indicates the degree of dissimilarity in bird species composition between these types, and the size of each ellipse is proportional to the degree of dissimilarity among the replicates (in this case, transects) within a particular vegetation or land use category (Shahabuddin *et al*., 2021). Additionally, we quantified the compositional differences between the studied vegetation or land use types using Per-mutational Analysis of Variance (PERMANOVA), employing both abundance-based Bray-Curtis and incidence-based Jaccard indices to determine whether these patterns in species compositional dissimilarity were driven by species relative abundances or simply by species presence or absence (Shahabuddin *et al*., 2021). The statistical significance was evaluated with an alpha of 0.05 based on 999 permutations.

Result and Discussion

During the research, periods a total of 66 birds species belonging to 18 families and 11 orders were recorded from the Tighra Reservoir. Among these, 44 species were migrants, 22 residents. The majority of the aquatic birds observed in this study were either migratory or residential migratory. Similar findings were reported by Ram Kumar Lodhi (2017), who also recorded 56 species from the Tighra Reservoir, and Bidhya Lakshmi Pataliputra (2022), who recorded 40 species in Gwalior. A checklist of bird species, including their occurrence status, residential status, and scientific names, is provided in TABLE 2. Of the 66 species, most (13 species) belong to the Anatidae family (see fig. 3). Among the total species recorded, most were of least concern (57 species), while 4 species were vulnerable, and 5 species were near threatened. The study found that 67% of the birds were migrants, 33% were Resident. The status of certain bird species, such as the Spot-billed Duck, Common Moorhen, Great Cormorant, Grey Heron, Large Egret, and Intermediate Egret observed in Chhilchhila Wildlife Sanctuary, differed from their status in Haryana as noted by Tak *et al*. (2010). There was a visible variation in the number of aquatic bird species recorded across the summer, winter, rainy seasons. According to Lameed (2011), species that are winter visitors use wetlands for rest and other activities while awaiting favorable conditions in their home range. The number of aquatic birds' species were highest in winter and lowest during rainy season. The presence of migratory birds in the area indicates the habitat is critical for these organisms. Additionally, the presence of these aquatic birds shows that the area provides most suitable environment for nesting, breeding, feeding.

Table 2: List of Aquatic avifauna observed in Tighra fresh water Reservoir

Checklist of aquatic avian fauna observed in Tighra fresh water reservoir Gwalior (M.P.)						
S. No.	**Order**	**Family**	**Scientific name**	**Species name**	**IUCN Status**	**Res. Status**
1.	Pelecaniformes	Ardeidae	*Bubulcus ibis*	Cattle egret	LC	M
2.			*Ardea purpurea*	Purple heron	LC	M
3.			*Ardeola grayii*	Indian pond- heron	LC	R
4.			*Ardea cinerea*	Grey heron	LC	R
5.			*Ardea intermedia*	Intermediate egret	LC	M
6.			*Egretta garzetta*	Little Egret	LC	R
7.			*Nycticorax nycticorax*	Night heron	LC	M
8.		Threskiornithidae	*Eudocimus albus*	White ibis	LC	R
9.			*Platalea leucorodia*	Eurasian spoonbill	LC	M
10.			*Pseudibis papillosa*	Red naped ibis	LC	R
11.	Anseriformes	Anatidae	*Anas poecilorhyncha*	Spot-billed duck	LC	M
12.			*Anas crecca*	Common teal	LC	M
13.			*Sarkidiornis sylvicola*	Comb duck	LC	M
14.			*Dendrocygna javanica*	Lesser whistling duck	LC	R
15.			*Netta rufina*	Red crested pochard	LC	M
16.			*Aythya ferina*	Common pochard	VU	M
17.			*Anas acuta*	Northern pintail	LC	M
18.			*Spatula clypeata*	Northern shoveler	LC	M
19.			*Mareca strepera*	Gadwall	LC	M
20.			*Anser anser*	Greylag goose	LC	M

21.			*Tadornna ferruginea*	Ruddy shelduck	LC	M
22.			*Nettapus coromandelianus*	Cotton pygmy goose	LC	M
23.			*Anas platyrhynchos*	Mallard	LC	M
24.	Ciconiiformes	Ciconiidae	*Mycteria leucocephala*	Painted stork	LC	R
25.			*Anastomus oscitans*	Asian Openbill	LC	R
26.			*Ciconia episcopus*	Asian woollyneck	NT	R
27.	Charadriiformes	Recurvirostridae	*Himantopus himantopus*	Black winged stilt	LC	M
28.			*Vanellus malarbaricus*	Yellow wattled Lapwing	LC	R
29.			*Charadrius dubius*	Little ringed plover	LC	M
30.			*Vanellus indicus*	Red wattled lapwings	LC	R
31			*Vanellus duvaucelii*	River lapwing	NT	R
32.		Jacanidae	*Metopidius indicus*	Bronze-winged jacana	LC	R
33.			*Hydrophasianus chirurgus*	Pheasant-tailed jacana	LC	M
34.		Scolopacidae	*Tringa glareola*	Wood sandpiper	LC	M
35.			*Tringa ochropus*	Green sandpiper	LC	M
36.			*Actitis hypoleucos*	Common sandpiper	LC	M
37.			*Tringa nebularia*	Common greenshank	LC	M
38.			*Tringa totanus*	Common Redshank	LC	M
39.			*Limosa limosa*	Black-tailed Godwit	NT	M
40.			*Gallinago gallinago*	Common snipe	LC	M
41.			*Tringa stagnatilis*	Marsh sandpiper	LC	M
42.			*Numenius arquata*	Eurasian curlew	NT	M
43.			*Gallinago nemoricola*	Wood snipe	VU	M
44.			*Calidris minuta*	Little stint	LC	M
45.		Burhinidae	*Esacus recurvirostris*	Great thick-knee	NT	R
46.		Laridae	*Sterna aurantia*	River tern	VU	R
47.		Glareolidae	*Cursorius coromandelicus*	Indian courser	LC	R
48.	Podicipediformes	Podicipedidae	*Podiceps cristatus*	Great crested grebe	LC	M
49.			*Tachybaptus ruficollis*	Little grebe	LC	M
50.	Passeriformes	Motacillidae	*Motacilla citreola*	Citrine wagtail	LC	M
51.			*Motacilla alba*	White wagtail	LC	M
52.			*Motacilla cinerea*	Grey wagtail	LC	M
53.			*Motacilla flava*	Western yellow wagtail	LC	M
54.		Alaudidae	*Eremopterix griseus*	Ashy-crowned Sparrow-lark	LC	R
55.	Suliformes	Phalacrocoracidae	*Microcarbo niger*	Little cormorant	LC	R
56.			*Phalacrocorax carbo*	Great cormorant	LC	M
57.	Gruiformes	Rallidae	*Gallinula chloropus*	Common moorhen	LC	M
58.			*Fulica atra*	Common coot	LC	M
59.			*Amaurornis phoenicurus*	White breasted waterhen	LC	M
60.			*Porphyrio porphyrio*	Purple swamphen	LC	R
61.	Gruiformes	Gruidae	*Anthropoides virgo*	Demoiselle crane	LC	M
62.			*Grus antigone*	Sarus crane	VU	M
63.	Caprimulgiformes	Apodidae	*Apus affinis*	Little swift	LC	R
64.	Coraciiformes	Alcedinidae	*Ceryle rudis*	Pied kingfisher	LC	R
65.			*Halcyon gularis*	White-throated Kingfisher	LC	R
66.			*Alcedo atthis*	Common Kingfisher	LC	M

Table 3: List showing all for site wise species numbering seasonally

S. No.	Species Name	Rainy				Winter				Summer			
		S1	S2	S3	S4	S1	S2	S3	S4	S1	S2	S3	S4
1.	Cattle egret	10	35	10	9	10	30	2	10	10	40	10	27
2.	Purple heron	0	2	1	0	0	2	0	0	0	1	0	0
3.	Indian pond- heron	1	5	0	1	0	6	0	3	1	2	1	2
4.	Grey heron	0	1	0	1	0	3	0	2	0	1	1	1
5.	Intermediate egret	1	5	1	2	2	8	0	2	0	1	1	1
6.	Little Egret	2	9	1	1	10	20	10	6	5	10	5	9
7.	Night heron	0	1	0	0	0	1	0	1	0	1	0	0
8.	White ibis	0	3	0	2	1	9	2	1	0	5	1	1
9.	Eurasian spoonbill	-	-	-	-	1	10	1	5	-	-	-	-
10.	Red naped ibis	5	6	5	4	0	10	0	5	2	5	2	1
11.	Spot-billed duck	1	10	1	5	5	15	3	0	1	6	2	3
12.	Common teal	-	-	-	-	0	15	5	3	-	-	-	-
13.	Comb duck	1	5	1	1	0	7	0	7	-	-	-	-
14.	Lesser whistling duck	2	15	2	5	10	30	10	17	5	10	5	12
15.	Red crested pochard	-	-	-	-	10	40	10	11	-	-	-	-
16.	Common pochard	-	-	-	-	5	20	5	6	-	-	-	-
17.	Northern pintail	-	-	-	-	10	30	10	18	-	-	-	-

18.	Northern shoveler	-	-	-	-	10	30	10	2	-	-	-	-
19.	Gadwall	-	-	-	-	5	20	5	2	-	-	-	-
20.	Greylag goose	-	-	-	-	5	40	10	6	-	-	-	-
21.	Ruddy shelduck	-	-	-	-	2	8	0	2	0	2	1	1
22.	Cotton pygmy goose	-	-	-	-	5	10	2	5	-	-	-	-
23.	Mallard	-	-	-	-	10	10	0	10	-	-	-	-
24.	Painted stork	-	-	-	-	2	10	2	4	0	1	0	1
25.	Asian Openbill	1	3	0	2	2	8	0	4	1	7	1	2
26.	Asian woollyneck	-	-	-	-	0	4	0	3	0	1	1	1
27.	Black winged stilt	0	20	2	10	5	10	5	6	5	20	5	14
28.	Yellow wattled Lapwing	-	-	-	-	0	1	0	0	0	1	0	1
29.	Little ringed plover	-	-	-	-	1	5	0	1	-	-	-	-
30.	Red wattled lapwings	2	10	2	5	1	10	1	5	1	6	1	6
31	River lapwing	-	-	-	-	0	5	1	3	0	2	0	2
32.	Bronze-winged jacana	0	5	1	1	1	8	1	2	0	2	2	2
33.	Pheasant-tailed jacana	0	2	0	0	1	1	0	1	0	1	0	1
34.	Wood sandpiper	-	-	-	-	0	1	0	1	-	-	-	-
35.	Green sandpiper	-	-	-	-	1	3	0	2	-	-	-	-
36.	Common sandpiper	-	-	-	-	1	6	4	1	-	-	-	-
37.	Common greenshank	-	-	-	-	0	5	0	2	-	-	-	-
38.	Common Redshank	-	-	-	-	0	3	0	2	-	-	-	-
39.	Black-tailed Godwit	-	-	-	-	1	7	1	1	-	-	-	-
40.	Common snipe	-	-	-	-	0	2	0	1	-	-	-	-
41.	Marsh sandpiper	-	-	-	-	1	1	1	1	-	-	-	-
42.	Eurasian curlew	-	-	-	-	1	2	1	2	-	-	-	-
43.	Wood snipe	-	-	-	-	0	2	1	1	-	-	-	-
44.	Little stint	-	-	-	-	0	4	1	2	-	-	-	-
45.	Great thick-knee	-	-	-	-	0	1	1	1	0	1	0	1
46.	River tern	-	-	-	-	2	2	1	1	0	2	0	2
47.	Indian courser	-	-	-	-	0	1	1	1	-	-	-	-
48.	Great crested grebe	-	-	-	-	0	1	0	1	-	-	-	-
49.	Little grebe	-	-	-	-	0	1	0	0	-	-	-	-
50.	Citrine wagtail	-	-	-	-	0	4	1	3	2	6	2	2
51.	White wagtail	0	3	1	2	2	7	2	3	1	5	0	1
52.	Grey wagtail	0	4	2	2	2	6	2	3	1	6	1	1
53.	Western yellow wagtail	1	3	0	1	2	8	3	4	0	14	6	4
54.	Ashy-crowned sparrow-lark	0	3	0	2	1	2	1	2	0	1	1	1
55.	Little cormorant	2	8	1	3	8	60	10	11	10	30	10	16
56.	Great cormorant	-	-	-	-	5	20	5	4	-	-	-	-
57.	Common moorhen	0	3	0	2	1	2	1	4	0	5	5	10
58.	Common coot	-	-	-	-	20	84	37	12	-	-	-	-
59.	White breasted waterhen	0	5	0	2	0	1	1	1	0	2	0	2
60.	Purple swamphen	-	-	-	-	0	6	2	4	1	2	2	3
61.	Demoiselle crane	-	-	-	-	2	10	2	3	-	-	-	-
62.	Sarus crane	-	-	-	-	0	2	0	0	-	-	-	-
63.	Little swift	-	-	-	-	5	20	5	7	-	-	-	-
64.	Pied kingfisher	-	-	-	-	0	1	0	1	-	-	-	-
65.	White-throated Kingfisher	-	2	-	1	1	3	0	2	0	2	0	2
66.	Common Kingfisher	-	-	-	-	0	1	0	0	0	0	1	0

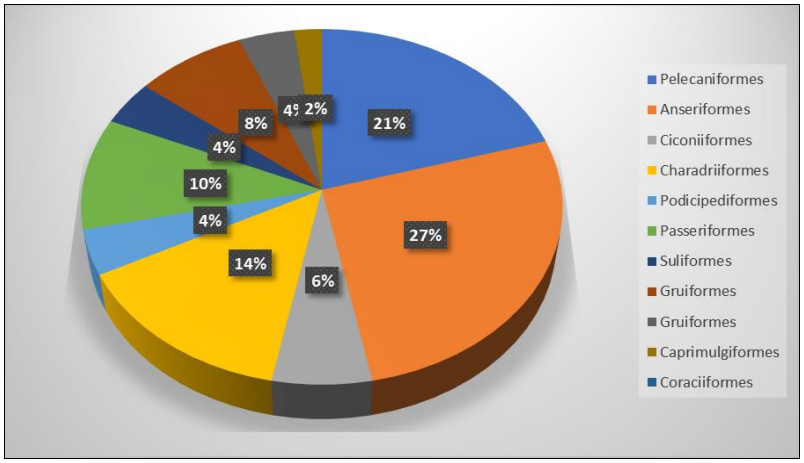

Fig 3: Pie chart showing the order wise birds species contribution in Tighra Reservoir

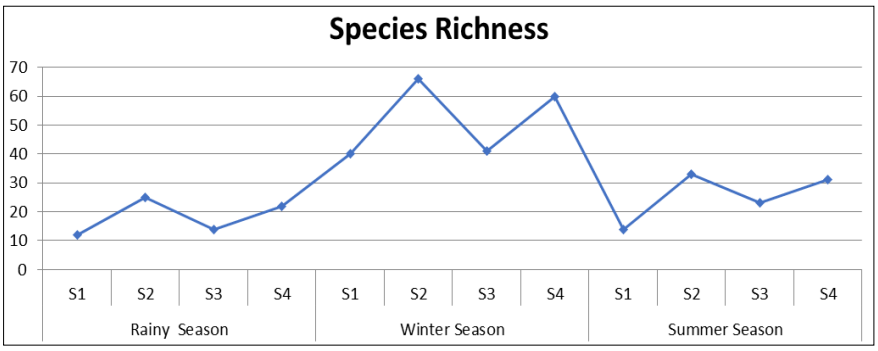

Fig 6: Graph showing Species Richness indices at different site in different season

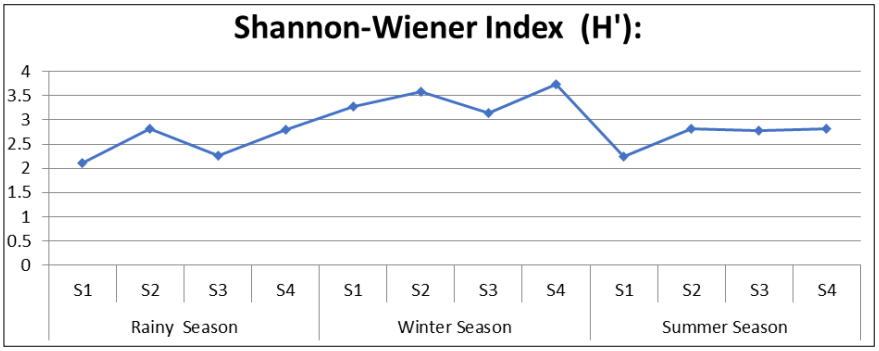

Fig 7: Graph showing Shannon - Wiener Index at different site in different season

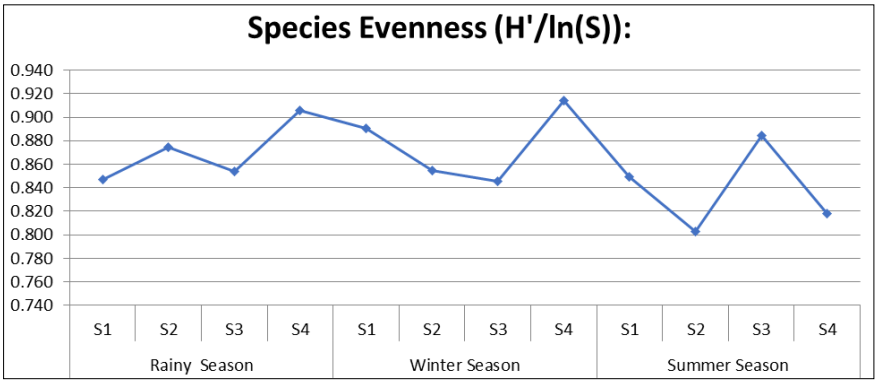

Fig 8: Graph showing Species Evenness indices at different site in different season

Conclusion

It was observed on the basis of finding that most of the birds species in that area are migratory, some are residential and residential migratory. Maximum diversity of aquatic birds shows that reservoir provides a best ecological habitat for aquatic birds species. The results indicates that highest birds species reflects the healthy reservoir conditions. The reservoir fulfill all the necessary requirements such as safe habitats, water, food sources for adult birds species and their young ones, also provide suitable roosting and nesting sites. These all factors are essential for the presence of variety of aquatic birds population. For the survival of both resident and migratory birds, preservation of reservoir are very important and it also provides diverse food resources and specialized micro-habitats which is essential for their well being.

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