RESEARCH ARTICLE

Avifauna and Comparative Study of Threatened Birds at Urban Wetlands of Kolhapur, Maharashtra, India

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ABSTRACT

Kolhapur is blessed with numbers of wetlands which is productive and unique ecosystem that support number of birds. The present study focus on avifaunal diversity and population status of threatened bird species by Diversity indices at in and around the wetlands of Kolhapur from 2016-2017. Bird survey was conducted according to line transect method and standard point count method. Species Diversity indices and Simpson index were used for statistical analysis. A total of 159 species of birds belonging to 17 orders and 60 families were recorded, of those 109 species of terrestrial birds and 50 species of water birds were observed. Out of 159 birds, 93 residential, 50 residential migratory and 15 are migratory. Of those one species is vulnerable, three species near threatened were observed. Among the birds recorded in study area, about 43% were insectivores and other dominating types include mixed diet 10%, piscivores 15%, omnivores 9%, carnivores 9%, granivores 9%, fructivores 2% and nectivores 3% respectively. Diversity of threatened birds was higher in Kalamba Lake as compare to other Wetlands. Urban wetlands are rich enough to attract birds and provide abundant food and safe passage for nesting, boosting and molting purpose.

Keyword: Threatened Birds, Species Diversity Indices, Simpson Index, Avifaunal diversity, Urban Wetland.

INTRODUCTION

Water is a basic and primary need of all vital processes and it is now well established that the life first arose in aquatic environment. As humans civilization is always grown around the water bodies or constructed ponds for their settlement and daily requirements, such type of wetlands had already started supporting flora and fauna along with avifauna. The birds are bio-indicators of ecosystems as the changes in the environment occur they respond by changing their composition, behavior and population (Bilgrami, 1995). Water birds are most important components of wetland ecosystem as they occupy several tropical levels in the food web of wetland

nutrient cycle (Custer and Osborne, 1977). Through the number of studies it can be stated that avifauna responses to urbanization and are enormously growing (Rathod and Padate, 2008).

The avifauna of India and Pakistan was studied by Ali and Ripley (1987). According to Pande et al. (2011) reported species number from Maharashtra was 568 from 83 families and 20 orders, many authors have contributed to avifaunal diversity and distribution records in Maharashtra since few decades. Bhivate and Patil (2016) reported 122 species belonging to 18 orders and 54 families from Shivaji University, Kolhapur.

The present study report the avian diversity along with their migration status, IUCN status, Feeding guilds, nesting and habitat use due to influence of urbanization on avifaunal diversity is compared between five wetlands which have different anthropogenic pressure but have same weather conditions in terms of Species diversity indices and Simpson index. A regular and meticulous study of these wetlands will absolutely help to keep a record of birds species (resident, migratory and Threatened), thus helping to restore as well as to maintain the present condition of all of the five wetlands.

MATERIAL AND METHODS

Study area:
Kolhapur is situated at south-west of Maharashtra and study conducted in and around the 5 wetlands sites of Kolhapur.

1. Rankala (W1) –
It is an artificial lake situated at centre of Kolhapur (Lat 16°41'15.84"N, Lon 74°12'41.59"E). The wetland is disturb by human activities such as washing clothes, washing livestock, boating, tourism but also there is a great amount of avifaunal diversity due to availability of large amount of food. Migratory and threatened bird species and nesting were observed around the wetland.

2. Rajaram lake (W2) (Shivaji University)–
It is situated in Shivaji university campus area (Lat16°40'46.50"N, Lon 74°15'54.65"E) and low affected by the human activities and have abundant diversity of avifauna and also migratory and threatened bird species visit.

3. Kalamba Lake (W3) –
It is an oldest lake from Kolhapur constructed during British rule, it is away from city (Lat 16°39'16.12"N, Lon 74°12'42.19"E) and has abundant amount of migratory and threatened bird species. Wetland is less disturbed by human activities.

4. Kandal gaon lake (W4) –
It is situated away from the city (Lat 16°37'52.80"N, Lon 74°14'44.54"E) and has low influence of human activities so has large amount of avifaunal diversity, the wetland water is used for agricultural processes and wetland is surrounded by agriculture.

5. New Palace (W5) –
The wetland is conserved and protected by fence around it and there is no direct influence of human activities though it is a tourism point, it is situated in

Fig.1. Location map of Wetlands of Kolhapur

city area (Lat 16°43'0.56"N, Lon 74°14'0.65"E). Migratory birds prefer to visit the wetland so as have abundant amount of food and nesting is abundantly seen of threatened bird species.

Methodology-

Binocular Olympus 10*50 X, was used for close observation of birds and for photography Cannon-EOS 700 D camera, with Lens 55-250 mm. Book of Indian Birds by Salim Ali (2002) and Birds of the Indian Subcontinent by Grimmet et al. (2014) were used as field guides and for preparing check list. Bird survey was also conducted according to line transect method (Sale and Berkmuller, 1988), standard point count method (Altmann, 1974). The data collected from the surveys were used to estimate diversity and status of bird species. The survey was conducted during January 2016 to February 2017. Survey was conducted for 3 days in a week in morning (7.00 am to 10.00am) and in evening (5.00 pm to 7.00pm).

Statistical and Data analysis-

Marking of water bodies has done with the help of Google Earth. Diversity Indices like Shannon Wiener Index (H'), Species Richness (d'), Evenness indices (j') (Shannon and Weaver, 1949). and Simpson Index (D) (Simpson, 1949) was use to estimate population status of threatened birds species.

Formula

1. Shannon Wiener Index (H')

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

Where, $Pi = \frac{\text{Number of individuals of otne species}}{\text{Total number of all individual(N)}}$

2. Species Richness (d')

$$d' = \frac{S-1}{\log(N)}$$

Where, S = total number of species

N = total number of individuals of all species

3. Evenness (j')

$$j' = \frac{H}{\log(S)}$$

Where, H = Shannon Wiener diversity index

S = total number of species

4. Simpson Index (D)

$$D = 1 - \frac{\sum n(n-1)}{N(N-1)}$$

Where, n = number of individuals of each species

N = total number of individuals of all species

RESULTS AND DISCUSSION

Wetlands are important bird habitats, birds utilize it for activities like feeding, breeding, nesting and rearing young ones. Kalamba lake has less urban pressure comparatively other wetlands, However it has high avifaunal diversity, almost same number of species are sited at Rankala Lake, Rajaram Lake and New palace lake, Kandal gaon lake has less count of water birds and high diversity of terrestrial birds.

Table.1. Consolidated Checklist of Birds of Wetlands of Kolhapur, along with status, feeding guild, IUCN Status.

Sr. No.	Common Name	Scientific Name	Family	Status	Feeding guild	IUCN Status
Order - Podicipitidae						
1	Little Grebe	*Tachybaptus ruficollis*	Podicipitidae	R	P	LC
Order - Pelecaniformes						
2	Large cormorant	*Phalacrocorax carbo*	Phalacrocoracdiae	RM	P	LC
3	Little cormorant	*Phalacrocorax niger*	Phalacrocoracdiae	R	P	LC
4	Indian shag/ Darter	*Phalacrocorax fuscicollis*	Phalacrocoracdiae	RM	P	LC
Order - Ciconiiformes						
5	Indian pond-heron	*Ardeola grayii*	Ardeidae	R	P	LC
6	Intermediate Egret	*Mesophoyx intermedia*	Ardeidae	M	P	LC
7	Cattle egret	*Bubulcus ibis*	Ardeidae	R	P	LC
8	Little egret	*Egretta garzetta*	Ardeidae	R	P	LC
9	Grey heron	*Ardea cinerea*	Ardeidae	R	P	LC
10	Purple heron	*Ardea purpuria*	Ardeidae	R	P	LC

Table.1. Continued..

Sr. No.	Common Name	Scientific Name	Family	Status	Feeding guild	IUCN Status
Order - Ciconiiformes						
11	Painted stork	*Mycteria leucocephala*	Ciconiidae	R	P	NT
12	wooly-Necked Stork	*Ciconia episcopus*	Ciconiidae	RM	P	VU
13	Asian open billed stork	*Anastomus oscitans*	Ciconiidae	R	P	LC
14	White-Headed Ibis	*Threskiornis melanocephalus*	Threskiornithidae	RM	P	NT
15	Black Ibis	*Pseudibis papillosa*	Threskiornithidae	RM	P	LC
16	Glossy Ibis	*Plegadis falcinellus*	Threskiornithidae	RM	P	LC
17	Eurasian spoonbill	*Anastomus oscitans*	Threskiornithidae	RM	P	LC
Order - Anseriformes						
18	Brahminy Shelduck	*Tadorna ferruginea*	Anatidae	M	P	LC
19	Common Teal	*Anas crecca*	Anatidae	M	P	LC
20	Spot-billed Duck	*Anus poecilorhyncha*	Anatidae	R	P	LC
21	Gadwall	*Anas strepera*	Anatidae	M	P	LC
Order - Falconiformes						
22	Black-Shouldered Kite	*Elanus caeruleus*	Accipitridae	R	C	LC
23	Shikra	*Accipiter badius*	Accipitridae	R	C	LC
24	Brahminy kite	*Haliastur indus*	Accipitridae	R	C	LC
25	Black Kite	*Milvus migrans*	Accipitridae	R	C	LC
26	Eurasian sparrowhawk	*Accipiter nisus*	Accipitridae	RM	C	LC
27	White-eyed Buzzard	*Butastur teesa*	Accipitridae	RM	C	LC
28	Crested Serpent-eagle	*Spilornis cheela*	Accipitridae	RM	C	LC
29	Western Marsh-Harrier	*Circus aeruginosus*	Accipitridae	M	C	LC
30	Common Kestrel	*Falco tinnunculus*	Falconidae	RM	C	LC
31	Osprey	*Pandion haliaetus*	Pandionidae	RM	C	LC
Order - Galliformes						
32	Painted Francolin	*Francolinus pictus*	Phasianide	R	O	LC
33	Grey Francoline	*Francolinus pondicerianus*	Phasianide	R	O	LC
34	Indian Peafowl	*Pavo cristatus*	Phasianide	R	O	LC
Order - Gruiformes						
35	White-Breasted Water Hen	*Amaurornis akool*	Rallidae	R	O	LC
36	Purple Moorhen	*Porphyrio porphyrio*	Rallidae	R	O	LC
37	Common Coot	*Fulica atra*	Rallidae	R	O	LC
Order - Charadriiformes						
38	Pheasant tailed jacana	*Hydrophasianus chirurgus*	Jacanidae	R	I	LC
39	Bronzed-Winged Jacana	*Metopidius indicus*	Jacanidae	R	I	LC
40	Marsh Sandpiper	*Tringa stagnatilis*	Charadriidae	M	I	LC
41	Common sandpiper	*Tringa hypoleucos*	Charadriidae	RM	I	LC
42	Wood sandpiper	*Tringa glareola*	Scolopacidae	M	I	LC
43	Common Tern	*Sterna hirundo*	Laridae	RM	I	LC
44	River tern	*Sterna aurantia*	Laridae	R	I	NT
45	Black winged stilt	*Himantopus himantopus*	Recurvirostridae	M	I	LC
46	Yellow wattled lapwing	*Vanellus malabaricus*	Charadriidae	RM	I	LC
47	Red wattled lapwing	*Vanellus indicus*	Charadriidae	R	I	LC
48	Little ringed plover	*Charadrius dabius*	Charadriidae	RM	I	LC
49	Little Stint	*Calidris minuta*	Charadriidae	M	I	LC
50	Temmincks Stint	*Calidris temminckii*	Charadriidae	M	I	LC

Table.1. Continued…

Sr. No.	Common Name	Scientific Name	Family	Status	Feeding guild	IUCN Status
Order - Columbiformes						
51	Yellow-Legged Green Pigeon	*Treron phoenicoptera*	Columbidae	RM	G	LC
52	Blue rock pigeon	*Columba livia*	Columbidae	R	G	LC
53	Spotted dove	*Streptopelia chinensis*	Columbidae	R	G	LC
54	Laughing dove	*Streptopelia senegalensis*	Columbidae	R	G	LC
55	Rufous turtle dove	*Streptopelia orientalis*	Columbidae	RM	G	LC
56	Eurasion Collared-dove	*Streptopelia decaocto*	Columbidae	RM	G	LC
Order - Psittaciformes						
57	Rose ringed parakeet	*Psittacula krameri*	Psittacidae	R	F	LC
58	Vernal Hanging Parrot	*Loriculus vernalis*	Psittacidae	RM	F	LC
Order - Cuculiformes						
59	Grey-bellied Cuckoo	*Cacomantis passerines*	Cuculida	RM	I	LC
60	Common Hawk Cuckoo	*Hierococcyx varius*	Cuculida	RM	I	LC
61	Pied crested cuckoo	*Clamator jacobinus*	Cuculida	RM	I	LC
62	Indian banded bay cuckoo	*Cacomantis sonneratii*	Cuculida	R	I	LC
63	Koel	*Eudynamys scolopacea*	Cuculida	R	F	LC
64	Southern Coucal	*Centropus sinensis*	Cuculida	R	I	LC
Order - Strigiformes						
65	Barn owl	*Tyto alba*	Tytonidae	R	C	LC
66	Spotted Owlet	*Athene brama*	Strigidae	R	C	LC
Order - Caprimulgiformes						
67	Indian Little Nightjar	*Caprimulgus asiaticus*	Caprimulgidae	R	I	LC
Order - Apodiformes						
68	Alpine swift	*Apus malba*	Apodidae	R	I	LC
69	House swift	*Apus affinis*	Apodidae	R	I	LC
Order - Coraciiformes						
70	Common kingfisher	*Alcedo atthis*	Alcedinidae	R	P	LC
71	Pied kingfisher	*Ceryl rudis*	Alcedinidae	R	P	LC
72	White breasted kingfisher	*Halcyon smyrensis*	Alcedinidae	R	P	LC
73	Indian roller	*Coracius benghalensis*	Coracidae	RM	I	LC
74	Asian green bee-eater	*Merops orientalis*	Meropidae	RM	I	LC
75	Hoopoe	*Upua epops*	Upupidae	RM	I/C/F	LC
76	Common grey hornbill	*Tockus birostris*	Bucerotidae	R	O	LC
Order - Piciformes						
77	Coppersmith Barbet	*Megalaima haemacephala*	Capitonidae	R	F/I	LC
78	White-cheeked Barbet	*Megalaima viridis*	Capitonidae	R	F/I	LC
79	Yellow-crowned Woodpecker	*Dendrocopos mahrattensis*	Picidae	R	I	LC
80	Rufous Woodpecker	*Micropternus brachyurus*	Picidae	R	I	LC
81	Black-rumped Flameback	*Dinopium benghalense*	Picidae	R	I	LC
Order - Passeriformes						
82	Ashy-crowned sparrow lark	*Eremopterix grisea*	Alaudidae	R	I	LC
83	Rufous-tailed finch-lark	*Ammomanes phoenicurus*	Alaudidae	R	I	LC
84	Malabar crested lark	*Galerida malabarica*	Alaudidae	R	I	LC
85	Sykes's crested lark	*Galerida deva*	Alaudidae	R	I	LC

Table.1. Continued…

Sr. No.	Common Name	Scientific Name	Family	Status	Feeding guild	IUCN Status
Order - Passeriformes						
86	Dusky Crag-Martin	*Hirundo concolor*	Hirundinidae	R	I	LC
87	Common Swallow	*Hirundo rustica*	Hirundinidae	RM	I	LC
88	House Swallow	*Hirundo tahitica*	Hirundinidae	R	I	LC
89	Wire-tailed Swallow	*Hirundo smithii*	Hirundinidae	R	I	LC
90	Red rumped swallow	*Hirundo daurica*	Hirundinidae	RM	I	LC
91	Rufous-Backed Shrike	*Lanius schach*	Laniidae	RM	F/C/I	LC
92	Great Grey Shrike	*Lanius excubitor*	Laniidae	RM	C	LC
93	Bay-backed Shrike	*Lanius vittatus*	Laniidae	R	C	LC
94	Eurasian Golden oriole	*Oriolus oriolus*	Corviidae	RM	C/F/I/G	LC
95	Black-Headed Oriole	*Oriolus xanthornus*	Oriolidae	RM	C	LC
96	Black drongo	*Dicrurus adsimilis*	Dicruridae	RM	I	LC
97	Ashy drongo	*Dicrurus leucophaeus*	Dicruridae	RM	I	LC
98	White-bellied drongo	*Dicrurus caerulescens*	Dicruridae	RM	I	LC
99	Rosy Starling	*Sturnus roseus*	Sturnidae	M	I	LC
100	Brahminy Starling	*Sturnus pagodarum*	Sturnidae	R	O	LC
101	Grey-Headed Starling	*Sturnus malabaricus*	Sturnidae	RM	O	LC
102	Common myna	*Acridotheris tristis*	Sturnidae	R	I/G	LC
103	Jungle myna	*Acridotheris fuscus*	Sturnidae	R	I/G/F	LC
104	Rufous Treepie	*Dendrocitta vegabunda*	Corvidae	R	O	LC
105	Jungle crow	*Corvus macrorhynchus*	Corvidae	R	O	LC
106	House crow	*Corvus spendense*	Corvidae	R	O	LC
107	Common Woodshrike	*Tephrodornis pondicerianus*	Vangidae	R	I	LC
108	Black-Headed Cuckoo-Shrike	*Coracina melanoptera*	Campephagidae	RM	I/F/G	LC
109	Scarlet minivet	*Pericrocotus flammeus*	Campephagidae	R	I	LC
110	Little minivet	*Pericrocotus cinnamomeus*	Campephagidae	R	I	LC
111	Common iora	*Aegithina tiphia*	Irenidae	R	I	LC
112	Golden fronted chloropsis	*Chloropsis aurifrons*	Chloropseidae	RM	F/I/N	LC
113	Red whiskered bulbul	*Pycnonotus jocosus*	Pycnonotidae	R	F/I	LC
114	Red vented bulbul	*Pycnonotus cafer*	Pycnonotidae	R	F/G/I/C	LC
115	Common Babbler	*Turdoides caudatus*	Leiotrichidae	R	I	LC
116	Large Grey Babbler	*Turdoides malcolmi*	Leiotrichidae	R	G/I	LC
117	Jungle babbler	*Turdoides striatus*	Muscicapidae	R	O	LC
118	Yellow eyed babbler	*Chrysomma sinense*	Sylviidae	R	N/I	LC
119	Puff-throated babbler	*Pellorneus ruficeps*	Pellorneidae	R	I	LC
120	Red-Breasted Flycatcher	*Ficedula parva*	Muscicapidae	M	I	LC
121	Tickell's blue flycatcher	*Muscicapa tickllіae*	Muscicapidae	RM	I	LC
122	Asian Paradise-flycatcher	*Terpsiphone paradise*	Muscicapidae	RM	I	LC
123	White-bellied Blue Flycatcher	*Cyornis pallipes*	Muscicapidae	RM	I	LC
124	Verditer flycatcher	*Eumyias thalassinus*	Muscicapidae	RM	I	LC
125	Bluethroat	*Luscinia svecica*	Muscicapidae	M	I	LC
126	Magpie robin	*Copsychus saularis*	Muscicapidae	R	I	LC
127	Stone chat	*Saxicola torquata*	Muscicapidae	RM	I	LC
128	Pied bush chat	*Saxicola caprata*	Muscicapidae	R	I	LC
129	Indian robin	*Saxicoloides fulicata*	Muscicapidae	R	I	LC

Table.1. Continued…

Sr. No.	Common Name	Scientific Name	Family	Status	Feeding guild	IUCN Status
Order - Passeriformes						
130	Blue Rock Thrush	*Monticola solitaries*	Muscicapidae	RM	O	LC
131	White-spotted fantail	*Rhipidura albogularis*	Rhipiduridae	R	F/I	LC
132	Plain Prinia	*Prinia inornata*	Cisticolidae	R	I	LC
133	Ashy Prinia	*Prinia socialis*	Cisticolidae	R	I	LC
134	Jungle Prinia	*Prinia sylvatica*	Cisticolidae	R	I	LC
135	Common Tailorbird	*Orthotomus sutorius*	Cisticolidae	R	N/I	LC
136	Blyth's reed warbler	*Acrocephalus dumetorum*	Acrocephalidae	RM	I	LC
137	Clamorous reed warbler	*Acrocephalus stentoreus*	Acrocephalidae	RM	I	LC
138	Common ChiffChaf	*Phylloscopus collybita*	Phylloscopidae	R	I	LC
139	Great tit	*Parus major*	Paridae	R	I	LC
140	Paddy field pipit	*Anthus novaeseelandiae*	Motacillidae	RM	I	LC
141	Olive-backed Pipit	*Anthus hodgsoni*	Motacillidae	RM	I	LC
142	Forest wagtail	*Motacilla indica*	Motacillidae	RM	I	LC
143	Yellow wagtail	*Motacilla flava*	Motacillidae	M	I	LC
144	Large pied wagtail	*Motacilla maderaspatensis*	Motacillidae	RM	I	LC
145	White wagtail	*Motacilla alba*	Motacillidae	M	I	LC
146	Thick bellied flower pecker	*Dicaeum concolor*	Dicaeidae	R	N	LC
147	Tickell's flowerpecker	*Dicaeum agile*	Dicaeidae	R	N	LC
148	Plaincoloured flowerpecker	*Dicaeum erythrorynchos*	Dicaeidae	R	N	LC
149	Purple rumped sunbird	*Nectarinia zeylonica*	Nectarinidae	R	N	LC
150	Puple sunbird	*Nectarinia asiatica*	Nectarinidae	R	N	LC
151	Oriental White eye	*Zosterops palpebrosa*	Zosteropidae	R	N/I	LC
152	House sparrow	*Passer domesticus*	passerinae	R	G	LC
153	Yellow throated sparrow	*Petronia xanthocollis*	passerinae	R	G	LC
154	Baya Weaver	*Ploceus philippinus*	Ploceidae	R	G	LC
155	Spotted munia	*Lonchura punctualata*	Estrildinae	R	G	LC
156	Red munia	*Esterilda amandava*	Estrildinae	R	G	LC
157	Black headed munia	*Lonchura malacca*	Estrildinae	R	G	LC
158	Indian Silverbill	*Lonchura malabarica*	Estrildinae	R	G	LC
159	White rumped Munia	*Lonchura striata*	Estrildinae	R	G	LC

Feeding Guild: C-Carnivore; F-Frugivore; G-Granivore; I-Insectivore; N-Nectarivore; O-Omnivore; P-Piscivore
Status: R-Resident; RM-Resident Migrant; M- Migrant
IUCN Category: LC-Least Concern, NR-Near Threatened, V-Vulnerable

Table.2. Comparison of Diversity indices and Occurrence of Threatened species for different wetland Habitats.

Wetland Habitats	Shannon Wiener Index (H')	Species Richness (d')	Evenness index (j')	Simpson Index (D)	Occurrence of Threatened species			
					S1	S2	S3	S4
W1	0.4967	1.2884	0.8250	0.6705	+	-	+	+
W2	0.4740	0.9461	0.9935	0.6674	+	-	+	+
W3	0.5053	1.3861	0.8393	0.6764	+	+	+	+
W4	0.4619	1.0733	0.9681	0.6538	+	-	+	+
W5	0.4966	1.2642	0.8249	0.6721	+	-	+	+

Wetland Habitat = W1-Rankala; W2-Rajaram lake; W3-Kalamba Lake; W4-Kandal gaon lake; W5-New Palace
Occurrence of Threatened species = S1- Painted stork, S2- Wooly-Necked Stork, S3-White-Headed Ibis, S4-River tern, + Sighted, - Not sighted

Black –winged Stilt

Great tit

Black Headed Ibis

Spotted Munia

Median Egret

Purple Heron

Yellow Wagtail

Large Egret

Indian-magpie Robin

Wooly-Necked Stork

Painted Stork

Pied Kingfisher

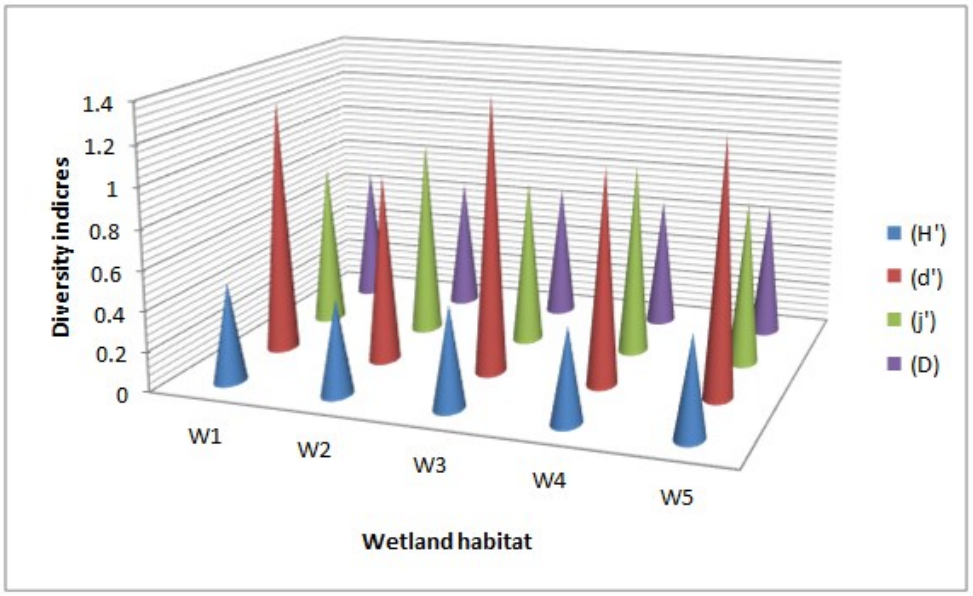
During study period, a total 159 species of birds belonging to 17 orders and 60 families were recorded (Table 1), of those 109 species of terrestrial birds belonging to 9 orders and 43 families and 50 species of water birds belonging to 8 orders and 17 families were recorded. Out of 159 birds, 93 are residential, 50 are residential migratory and 15 are migratory (Table 1). Of those one species is vulnerable (*Ciconia episcopus*), three near threatened species were observed (.i.e. *Mycteria leucocephala, Threskiornis melanocephalus, Sterna aurantia*) as per IUCN Red list (IUCN (2017), *Ciconia episcopus* which is vulnerable species was only sited at Kalamba lake, *Mycteria leucocephala, Threskiornis melanocephalus* and *Sterna aurantia* threatened species were sited at all wetlands during study period (Table 2) same findings was reported by Bhivate and Patil (2016) at Shivaji University campus, Kolhapur district. In the previous study migrant birds

like Wigeon (*Anas penelope*) and Showeller (*Anasclypetata*) were sited by Kachare et al., 2011, but during the study period these species were not encountered. Raptors like Black-Shouldered Kite, Eurasian sparrow hawk, White-eyed Buzzard, Crested Serpent-eagle, Western Marsh-Harrier and Osprey were sited during migration.

Wetlands being a highly productive area attract birds with varying feeding habits. Birds were classified into 6 groups on the bases of feeding guilds. Among the birds species 67 were insectivores, 24 piscivores, 16 mixed diet, 14 omnivores, 15 carnivores, 14 granivores, 3 fructivores and 5 nectivores respectively (Table 1). Similar dominancy of insectivorous bird population was reported in Krishna river basin at sangli district by Kumbar and Ghadage (2013) and sothuparai reservoir, periyakulam, theni district, tamilnadu by Mary et al. (2015).

Among the 17 orders Passeriformes dominate with 78 species followed by Charadriiformes (14), Ciconiiformes (13) and Falconiformes (12). Most of the family represent by one or two species. Largest species was represented in Muscicapidae (12) followed by Accipitridae (8) and Arceidae (6) (Table 1). Wooly-Necked Stork, White-Headed Ibis, Indian Paradise flycatcher, Red-Breasted Flycatcher and Bluethroat were some important observations. Painted stork, Little Cormorants, Spot-billed Duck were commonly observed and have abundant population in all the wetlands. Nesting of aquatic birds and terrestrial birds were recorded during the study period around the wetlands, Total 415 nesting were recorded, out of which 325 were of aquatic birds nest and 90 were of terrestrial birds.

Shannon wiener index, Species richness, Evenness index, Simpson index of threatened bird species were studied on different wetland habitats (Table 2). The density of threatened bird species were maximum at wetland W3 at the same time Shannon wiener index (H'), Species richness (d') and Simpson index (D) were recorded high for W3 continuing W1and W5 However Shannon Wiener (H') and Simpson index (D) has low density in W4 Species Richness (d') is low in W2. Evenness index were recorded higher at W2 and lower in W5 respectively (Table 2). The Shannon-Weiner Diversity Index which specifies the comparative occurrence of many species was used to associate species abundance and relative richness amongst species (Whittaker, 1977). High value of diversity indices and species richness and simpson index indicates the conductive environment of wetlands, similar observations were seen at irrigation reserviour of savli taluka, district Vadodara by Rathod and Padate (2008).



Wetland Habitat = W1-Rankala; W2-Rajaram lake; W3-Kalamba Lake; W4-Kandal gaon lake; W5-New Palace
Diversity Indices = Shannon Wiener Index - (H'); Species Richness - (d'); Evenness index - (j'); Simpson Index - (D

Fig.2. Diversity indices of different wetland habitat

Table.3. Species distribution in their respected order

Sr. No	Orders	Number of species	Percentage %
1	Podicipitidae	1	0.62
2	Pelecaniformes	3	1.88
3	Ciconiiformes	13	8.17
4	Anseriformes	4	2.51
5	Falconiformes	10	6.23
6	Galliformes	3	1.88
7	Gruiformes	3	1.88
8	Charadriiformes	13	8.17
9	Columbiformes	6	3.77
10	Psittaciformes	2	1.25
11	Cuculiformes	6	3.77
12	Strigiformes	2	1.25
13	Caprimulgiformes	1	0.62
14	Apodiformes	2	1.25
15	Coraciiformes	7	4.40
16	Piciformes	5	3.14
17	Passeriformes	78	49
	Total	159	100

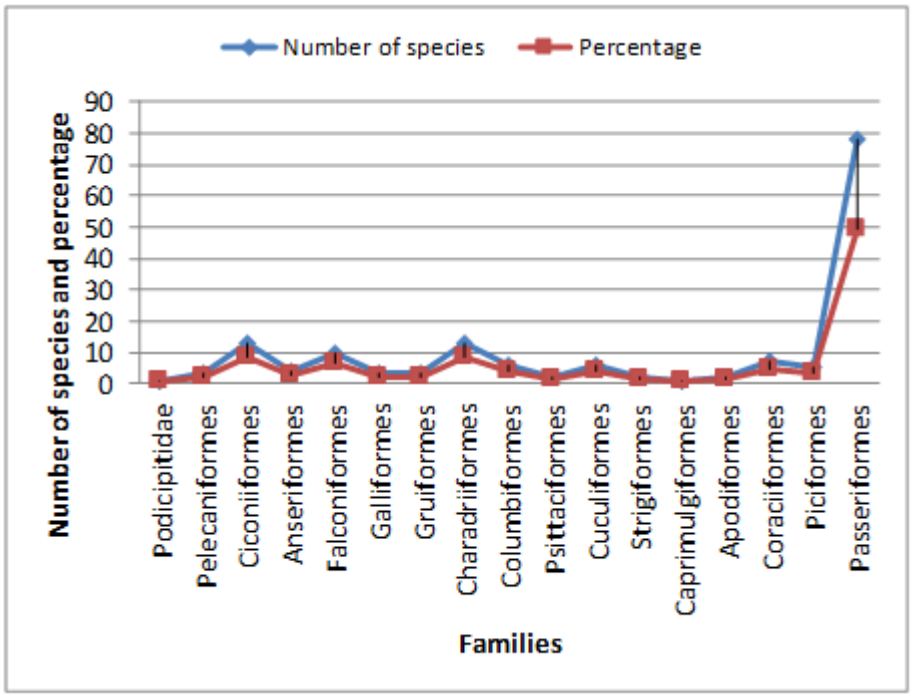


Fig.3. Showing Species distribution in their respected order

During study period various anthropogenic activities like tree cutting, urban encroachment, agriculture expansion, agricultural runoff, boating, washing clothes, washing livestock, tourism were observed in all the wetlands, all these activities are directly or indirectly responsible which is carrying out process of eutrophication of lakes, Kachare et al., (2011) observed same threats. Average noise level, or overall noise pollution, in a wetland site seems to negatively influence the bird richness and lower levels of noise pollution observed higher bird diversity (Teyla et al., 2015). People depending upon these ponds for their domestic needs like cloth washing, domestic animal drinking and washing purpose. So anthropogenic

activities and human influence directly or indirectly affects the avian fauna. There is need of conservations of wetlands for their further conservation of diversity of birds and associated biodiversity and to maintain environmental balance.

CONCLUSION

It can be said that due to the plantation around the urban wetlands the density of the terrestrial birds are more, these plantation act as a protecting shield for the aquatic birds from human activities as well as help in nesting the terrestrial and aquatic bird species. The Species diversity indices and Simpson index of all wetlands were higher during winter due to the arrival of migrant bird species. Habitat utilized by the *Ciconia episcopus* is selective and mostly seen in undisturbed and silent areas, during study period *Ciconia episcopus* was only encountered at Kalamba Lake which has less human pressure. Other wetlands also support residential, migratory and threatened bird species. This indicates that urban wetlands are rich enough to attract birds and provide abundant food and safe passage for nesting, boosting and molting purpose. Avifauna also act as an environmental indicator a slightly change in environment it respond by changing diversity, yearly monitoring will also help us providing useful information of environmental change.

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