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Aquatic bird diversity in Kondakarla Ava Lake wet land at Visakhapatnam, Andhra Pradesh, India

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Abstract
In the present investigation 65 species of water birds belonging to 8 orders, 21 families and 45 genera were recorded during the study period from June 2015 to May 2018 at Kondakarla Freshwater Lake. Orders, *Charadriiformes* were found to be the most dominant with 19 species followed by *Ciconiiformes* represented with 16 species, *Anseriformes* with 9 species, *Passeriformes* with 8 species, *Gruiformes* with 6 species, *Coraciiformes* with 4 species, *Pelecaniformes* with 2 species, *Podicipediformes* and *Columbiformes* were represented to one species each. The parentage of species composition was revealed that the abundance of avifauna was highest record, 39 species were common and occupied 60.00% in the total population, followed by the uncommon birds are 21 contributed to 32.31%, five species were rare category contributed to 7.68%. An average yearly population diversity was resulted that richness of species was 41.92, Shannon-Wiener diversity Index (H) was 1.56, Maximum possible diversity ln (S) 3.73 and Evenness (E) 0.42.

Keywords: bird fauna, population diversity, seasonal diversity, monsoon**,** shannon-wiener diversity index, richness and evenness

Introduction
Birds are ubiquitous animals that frequent both terrestrial and aquatic ecosystems and they have fantastic ability to move and most species are found only in particular regions. The birds are widespread due to their adaptability and feasibility of movements. The living species of birds are grouped into 27 Orders and these in turn have been grouped into 155 families (Kazmierczak and Van perto, 2000) [31]. Twelve percent of the bird species are threatened with extinction all over the world Rosser and Mainka, 2000 [39, 40]. Birdlife International, 2001 [14, 15]. Collar *et al*., 1994) [17]. Some people even destroying nests to discourage migratory birds from nesting the Wildlife (Protection) Act 1972.
Wetlands occupy 18.4% of the countries area (excluding river) of which 70% are under paddy cultivation. In India, it has been estimated that 4.1 million hectares are wetlands (excluding paddy fields, rivers, and streams), whereas 1.5 million hectares are natural and 2.6 million hectares are manmade. The coastal wetlands occupy 6750 sq.km and are largely determined by mangrove vegetation. Management of wetlands both fresh water and coastal, is more important as these areas have traditional values for fish, wildlife and man. A systematic management plan has to be drawn in an integrated way to recognize the user relationship between biological and physical components and seek to maximize the benefits that can be obtained from sustainable multiple uses.
The various reservoirs, shallow ponds and numerous tanks support wetland biodiversity and add to the countries wetland wealth. It is estimated that freshwater wetlands alone support 20 per cent of the known range of biodiversity in India (Deepa and Ramachandra, 1999) [18]. Wetlands in India occupy 58.2 million hectares, including areas under wet paddy cultivation (Directory of Indian Wetlands). The aim of the present study is to population of migratory and residence aquatic birds in Kondakarla Lake.

Methodology
Study area
Kondakarla Lake is the second largest natural fresh water lake in Andhra Pradesh located at a distance of 42 km from Visakhapatnam and 7 km from Anakapalle. It is located north-east of Kondakarla village, lies between latitudes 17°35'30" and 17°36'02" N, and longitudes 82°59᾽27″ and 83°1᾽0″ E. Four stations were selected for the study to the collection of bird diversity during the period June 2015 to May 2018. The field sites were selected based on heterogeneity of the lake habitat and its integration as principal components of the wetland.

Data collection
Field data information was collected using three methods i.e., transect walk, point transects and direct observations. Most of surveys on the wetland's avifauna were conducted between June 2015 to May 2018 using a transect line approach (Bibby *et al*., 1992 and 1996) [10, 11, 13] to extensively survey throughout the wetland area so as to assess the avifauna species and abundance. Line Transect method proved most efficient in terms of data collection per unit effort (Yallop *et al*., (2003) [46]. Rosenstock (2002) [38]. Woodcock, (1996) [45].
India based on direct observations i,e road side counts (Burnham *et al*., (1980); Simpson (1949) [43]. A total of 72 visits (2 visits per month) were spent in the field observing the bird diversity. Birds were observed from 6 a.m to 10 a.m and 4 p.m to 6.30 p.m the avifauna of the habitats was also

observed seasonally by using binoculars of focal length 10 x 50x and 8x X 40 x (Emlen, 1974) [19]. Identification of the bird species has been done as per descriptions in ornithological publications catalogues pictorial diagrams of various authors Krishnan (1981) [32]. McKinnonm and Philips, (1993) [35]. Ali and Ripley (1993) [2]; Woodcock, (1996) [45]; Greywall (1995) [22]. Ali (1996) [1]; Grimmett *et al*., (2001) [23]. Grewal *et al*., (2002) [21].

The nomenclature used here which was given by Manakkadan, and Pittie, (2001) [34] and Ali (1996) [1]. Standardised English common names of the birds were presented and identification was conformed from the descriptions Manakadan *et al*., (1998) [33].

The mean monthly variation was also calculated for all the water birds by employed mean, Standard deviation, range and coefficient of variation. Density of birds per hectare is calculated by dividing the total estimate of the population of each month by the total aquatic area of different tanks. The percentage of dominant waterfowl, composition of Herons, Egrets and Bitterns were calculated and estimated. Status and mean monthly variation of different waterfowl families were shown in graphical representation.

The relative abundance of a species was obtained by dividing the abundance of a species by the total abundance of all species combined based on the assumption that the frequently seen the species the more abundant it is (Bibby *et al*., (1992 and 2000) [10, 11, 12]. Rosenstock *et al*., (2002) [38]. Birds' diversity was calculated by using Shannon-Weiner diversity Index 'H' was calculated (Shannon and Wiener 1949) [42].

Results

In the present study 65 species of water birds belonging to 8 orders, 21 families and 45 genera were recorded during the study period from June 2015 to May 2018 at Kondakarla Freshwater Lake. List of birds including their order, family, genus, species, distribution status, habitat, food habits, abundance, IUCN (2019-2) and W(P)A status were recorded and presented in Table 1and 2.

Among the orders, *Charadriiformes* were found to be the most dominant with 19 species followed by *Ciconiiformes* represented with 16 species, *Anseriformes* with 9 species, *Passeriformes* with 8 species, *Gruiformes* with 6 species, *Coraciiformes* with 4 species, *Pelecaniformes* with 2 species, *Podicipediformes* and *Columbiformes* were represented to one species each.

Avifaunal Percentage Composition Represented In Different Orders during the Study Period from 2015-2018

Population diversity of order *Anseriformes*

During the study period the total of 9 species in two families, order *Anseriformes* were 5.91% highest in 2015-16, followed by 5.90% in 2016-17, 5.12% lowest in 2017-18 (Table 5, Fig 3). In *Dendrocygnidae* family the lesser whistling ducks were highest and the Comb ducks were lowest percentage was observed in the *Anatidae* family population.

Population diversity of order *Ciconiiformes*

During the study period the total 16 species in 3 families of order *Ciconiiformes* were highest 64.55% in 2015-16, followed by 67.00% in 2016-17, 67.64% in 2017-18 (Table 5, Fig 3). In *Ardeidae* family the Cattle egrets were highest percentage and the Reef egrets were lowest percentage in the total population.

Population diversity of order *Charadriiformes*

During the study period the total 19 species in 5 families of order *Charadriiformes* were highest 10.95% in 2015-16. Followed by 10.06% in 2016-17 and lowest was 9.15% in 2017-18 (Table 5, Fig 3). The Pheasant-tailed jacanas were highest percentage in the *Jacanidae* family and the Kentish plovers were lowest percentage in the *Charadriidae* family population.

Population diversity of order *Coraciiformes*

During the study period the total 4 species in 5 families of order *Coraciiformes* were contributed to highest 0.05% in 2015-16. Followed by 0.02% during 2016-17 and lowest was noted 0.04% in 2017-18 (Table 5, Fig 3). In *Alcedinidae family* the Small blue kingfisher were contributed to highest and the Swallows were lowest percentage contributed to in *Hirundinidae* family population.

Population diversity of order *Gruiformes*

During the study period the total 6 species in one family of order *Gruiformes* were highest 9.52% in 2015-16. Followed by 9.21% during 2016-17 and lowest was noted 9.64% in 2017-18 (Table 5, Fig 3). In *Rallidae* family the Indian Moorhen hens were highest and the Slaty breasted rails were lowest percentage in the total population.

Population diversity of order *Passeriformes*

During the study period the total 8 species in 3 families of order *Passeriformes* were highest 4.97% in 2015-16. Followed by 4.41% during 2016-17 and lowest was noted 5.24% in 2017-18 (Table 5, Fig 3). In *Dicruridae* family the Black drongos were contributed to highest and the large pied Wagtail were lowest in *Motacillidae* family population.

Population diversity of order *Pelecaniformes*

During the study period the total 2 species in two families of order *Pelecaniformes* were highest 41.60% in 2015-16. Followed by 31.56% during 2016-17 and lowest was noted 26.84% in 2017-18 (Table 5, Fig3). In *Phalacrocoracidae* family the little cormorants were highest and the Darters were lowest *Anhingidae* family in the total population.

Population diversity of order *Podicipediformes*

During the study period the total one species of little grebes in one *Podicipedidae* family of order *Podicipediformes* was highest (0.90%) in 2015-16. Followed by (0.59%) during 2016-17 and lowest was recorded 0.71% in 2017-18 (Table 5, Fig 3).

The study results were observed the population of bird species in their number were gradually declined from 2015-2018 (Fig 4).

Avifaunal abundance at Kondakarla Freshwater Lake

The parentage of species composition was revealed that the abundance of avifauna was highest record, 39 species were common and occupied 60.00% in the total population, followed by the uncommon birds are 21 contributed to 32.31%, five species were rare category contributed to 7.68%. The percentage of species dominance exhibit that Common > UN Common > Rare (Table 26, Fig20).

Avifaunal IUCN (2019-2) and W (P) A status – 1972

According to IUCN (2019.2), fifty eight species were contribute to highest (89.23%) are least concerned (LC), six species (09.23%) are near threaten (NT), the lowest one species is vulnerable (1.54%) (VU) in the total avifauna (Table 27, Fig 21). According to Wild life Protection Act (1972), 63 species were highest represented to 96.92% Schedule- IV category, one species represented (1.54%) in Schedule- I category and data deficient (Table 27, Fig 22).

Avifauna population diversity index average from 2015-2018

Shannon-Wiener average diversity indices of fish species in Kondakarla freshwater lake found variation from 2015 to 18. The population index clearly indicated that the highest index shows in monsoon period and lowest in pre-monsoon period. Shannon-wiener diversity (H) was highest in November with 2.31 and lowest in May with 1.36. Species richness was highest in November with 54.00 and lowest in May with 34.33. The maximum diversity (ln(S) was recorded highest in November with 3.99 and the lowest was recorded 3.54 in May. The bird species diversity evenness (e) is highest 0.58 in November and lowest was 0.39 in May (Table 31, Fig 26).

The diversity index was more in post monsoon and lowest in pre monsoon periods. The comparisons and analysis of three consequent years result was exhibited that the avian population number gradually declined the richness of bird species, Shannon-Wiener diversity Index (H), the maximum possible diversity ln (S) and Diversity Evenness (E) clearly indicated that in various months from 2015 to 2018.

Avifaunal seasonal diversity index from 2017 to 2018

The average seasonal population diversity index was from 2017 to 2018 represented in Table 37, Fig 32. The richness of species was highest contributed to 48.00 during post-monsoon period, followed by monsoon 39.00 and the lowest population was indicated in pre-monsoon 38.75. Shannon-Wiener diversity Index (H) results indicated that the highest 1.85 during post-monsoon period, followed by monsoons and pre-monsoons which contributed to each with 1.42. The maximum possible diversity ln (S) was highest 3.87 during post-monsoon period, followed by monsoons which contributed to 3.66 and the lowest population was indicated in pre-monsoons 3.65. Avian population Evenness (e) was highest 0.48, during post-monsoon period, followed by monsoon and pre-monsoons contributed to each with 0.39.

Average yearly population diversity was resulted that richness of species was 41.92, Shannon-Wiener diversity Index (H) was 1.56, Maximum possible diversity ln (S) 3.73 and Evenness (E) 0.42.

Table 1: List of Birds recorded at Kondakarla Freshwater Lake

Order	Family	Sl. No	Common Name	Scientific Name
Anseriformes	*Dendrocygnidae*	1	Lesser whistling duck	*Dendrocygna javanica*
		2	Brahminy duck	*Tadorna ferruginea*
	Anatidae	3	Pintail duck	*Anas acuta*
		4	Common teal	*Anas crecca*
		5	Shoveller	*Anas clypeata*
		6	Wigeon	*Anas Penelope*
		7	Gargeny	*Anas querquedula*
		8	Cotton teal	*Nettapus coromandelianus*
		9	Comb duck	*Sarkidiornis melanotos*
Ciconiiformes	*Ardeidae*	10	Grey heron	*Ardea cinerea*
		11	Purple heron	*Ardea purpurea*
		12	Pond heron	*Ardeola grayii*
		13	Cattle egret	*Bubulcus ibis*
		14	Large egret	*Casmerodius alba*
		15	Little egret	*Egretta Grarzetta*
		16	Reef egret	*Egretta gularis*
		17	Median egret	*Egretta intermedia*
		18	Cinnamon bittern	*Ixobrychus cinnamoneus*
		19	Yellow bittern	*Ixobrychus sinensis*
		20	Night heron	*Nycticorax nycticorax*
	Ciconiidae	21	Open billed stork	*Anastomus oscitans*
		22	Lesser adjutant stork	*Leptoptilos javanices*
		23	Painted stork	*Mycteria leucocephala*
	Threskiornithidae	24	Large whistling teal	*Dendrocygna bicolor*
		25	Black-headed ibis	*Threskiornis melanocephalus*
Charadriiformes	*Jacanidae*	26	Pheasant-tailed jacana	*Hydrophasianus chirurgus*
		27	Bronze winged jacana	*Metopidius indicus*
		28	Redwattled lapwing	*Vanellus indicus*
		29	River lapwing	*Vanellus duvaucalii*
		30	Yellow-wattled lapwing	*Vanellus malabaricus*
	Recurvirostridae	31	Black winged stilt	*Himantopus himantopus*
	Charadriidae	32	Spotted sandpiper	*Actitis macularius*
		33	Little ringed plover	*Charadrius dubius*
		34	Kentish plover	*Charadrius alexandrinus*
		35	Little stint	*Calidris minutus*
		36	Common snipe	*Gallinago gallinago*
		37	Spotted red shank	*Tringa erythropus*

		38	Wood sandpiper	*Tringa glareola*
		39	Common sandpiper	*Tringa.hypoleucos*
		40	Marsh sandpiper	*Tringa stagnatilis*
	Burhinidae	41	Stone curlew	*Burhinus oedicnemus*
	Laridae	42	Brown headed gull	*Larus brunnicephalus*
		43	Black headed gull	*Larus rudibundus*
		44	River tern	*Sterna aurantia*
Coraciiformes	*Alcedinidae*	45	Small blue kingfisher	*Alcedo atthis*
	Cerylidae	46	Pied kingfishser	*Ceryle rudis*
	Halcyonidae	47	White breasted kingfisher	*Halcyon smyrnensis*
	Hirundinidae	48	Swallow	*Hirundo rustica*
Gruiformes	*Rallidae*	49	White breasted waterhen	*Amaurornis phoenicurus*
		50	Common Coot	*Fulica atra*
		51	Slaty breasted rail	*Rallus striatus*
		52	Water cock	*Gallicrex cinerea*
		53	Indian moorhen	*Gallinula chloropus*
		54	Purple moorhen	*Porphyrio porphyrio*
Passeriformes	*Dicruridae*	55	Black drongo	*Dicrurus adsimilis*
		56	Whitebellied drongo	*Dicrurus caerulescens*
	Motacillidae	57	Paddyfield pipit	*Anthus novaeseelandiae*
		58	Grey wagtail	*Motacilla caspica*
		59	Large pied wagtail	*Motacilla madaraspatensis*
		60	Brown shrike	*Lanius cristatus*
		61	Long tailed shrike	*Lanius Schach*
	Ploceidae	62	Baya weaver bird	*Ploceus philippinus*
Pelecaniformes	*Phalacrocoracidae*	63	Little cormorant	*Phalacrocorax niger*
	Anhingidae	64	Snake bird/ Darter	*Anhinga rufa*
Podicipediformes	*Podicipedidae*	65	Little grebe	*Podiceps ruficollis*

Table 2: Avifaunal distribution, habitat, food habitat, abundance, and IUCN and W (P) A status

Sl. No	Scientific Name	Distribution Status	Food Habits	Abundance	IUCN	W(P)A status
1	Lesser whistling duck	WV/LM Br.V	Veg/Pis	Com	LC	Sch-IV
2	Brahminy duck	WV/ LM/R	Veg/Pis	Com	LC	Sch-IV
3	Pintail duck	WV/ LM	Veg/ Inc	Com	LC	Sch-IV
4	Common teal	WV	Veg	Com	LC	Sch-IV
5	Shoveller	WV	Cru/Inc	UnCom	LC	Sch-IV
6	Wigeon	WV	Veg	Com	LC	Sch-IV
7	Gargeny	WV/ LM	Veg/ Aqu.inc	Com	LC	Sch-IV
8	Cotton teal	WV	Veg	UnCom	NT	Sch-IV
9	Comb duck	WV	Veg/ Aqua. Inc	UnCom	LC	Sch-IV
10	Grey heron	R/LM	Pis/ Ins	Com	LC	Sch-IV
11	Purple heron	R/LM	Pis	Com	LC	Sch-IV
12	Pond heron	R/ LM	Pis	Com	LC	Sch-IV
13	Cattle egret	R/LM	Inc/ Car	Com	LC	Sch-IV
14	Large egret	R/LM	Pis/ Car	Com	LC	Sch-IV
15	Little egret	R/LM	Pis/ Cru/ Ins	Com	LC	Sch-IV
16	Reef egret	R/LM	Ins /Moll/Pis	UnCom	LC	Sch-IV
17	Median egret	R/LM	Ins /Moll/Pis	UnCom	LC	Sch-IV
18	Cinnamon bittern	R/LM	Pis/ Moll/ Ins/Car	Com	LC	Sch-IV
19	Yellow bittern	R/ LM	Pis/ Car	UnCom	LC	Sch-IV
20	Night heron	R/LM	Pis/ Car	Com	LC	Sch-IV
21	Open billed stork	R/LM Br.V	Moll/Inc	Com	LC	Sch-IV
22	Lesser adjutant stork	R/LM/Br.V	Moll/Pis	Uncom	VU	Sch-IV
23	Painted stork	R/LM/Br.V	Pis/Snk/fro	Com	NT	Sch-IV
24	Large whistling teal	WV/ Br.V	Aqua. Veg/Pis/Moll	UnCom	NT	Sch-I
25	Black-headed ibis	R/LM/ WV Br.V	Pis/ Aqu.Inc	Com	NT	Sch-IV
26	Pheasant-tailed jacana	R	Veg/ Inc/ Moll	Com	LC	Sch-IV
27	Bronze winged jacana	R	Veg/Inc/ Moll	Com	LC	Sch-IV
28	Redwattled lapwing	R/ LM	Inc/ Moll	Com	LC	Sch-IV
29	River lapwing	R/ LM	Inc/ Moll	UnCom	LC	Sch-IV
30	Yellow-wattled lapwing	R/ LM	Inc/ Moll	Com	LC	Sch-IV
31	Black winged stilt	R/ LM Br.V	Moll /Inc	UnCom	LC	Sch-IV
32	Spotted sandpiper	WV/LM/R	Car/ Inc/Cru/Moll	UnCom	NT	Sch-IV
33	Little ringed plover	WV/LM/R	Car/ Inc/Cru/Moll	UnCom	LC	Sch-IV
34	Kentish plover	R/ WV/ LM	Cru/ Inc	UnCom	LC	Sch-IV
35	Little stint	WV/ R	Moll/ Crus/ Inc	R	LC	Sch-IV
36	Common snipe	LM/ WV	Inc/Moll/ Se	Com	LC	Sch-IV

37	Spotted red shank	WV	Moll/ Cru/Inc	UnCom	LC	Sch-IV
38	Wood sandpiper	WV	Moll/ Inc/ Pis	R	LC	Sch-IV
39	Common sandpiper	WV/ R	Cru/Aqu.Inc	Com	LC	Sch-IV
40	Marsh sandpiper	WV/ R	Cru/Aqu.Inc	R	LC	Sch-IV
41	Stone curlew	WV/ R	Cru/Aqu.Inc	UnCom	LC	Sch-IV
42	Brown headed gull	WV	Pis /Cru	Com	LC	Sch-IV
43	Black headed gull	WV	Pis	UnCom	LC	Sch-IV
44	River tern	LM/ R	Pis/ Aqua. Inc/Cru	Com	NT	Sch-IV
45	Small blue kingfisher	R	Pis/ Inc	Com	LC	Sch-IV
46	Pied kingfishser	R	Pis/ Inc	Com	LC	Sch-IV
47	White breasted kingfisher	R	Pis/ Inc	Com	LC	Sch-IV
48	Swallow	LM/R	Inc	Com	LC	DD
49	White breasted waterhen	WV	Inc/mol/Aq.we	Com	LC	Sch-IV
50	Coot	WV	Inc/mol/Aq.we	Com	LC	Sch-IV
51	Slaty breasted rail	WV	Inc/mol/Omn	Com	LC	Sch-IV
52	Water cock	R/LM	Inc/mol/Veg/Omn	Com	LC	Sch-IV
53	Indian moorhen	R/LM	Inc/moll/Veg/Omn	Com	LC	Sch-IV
54	Purple moorhen	R	Veg/ Moll/ Inc	Com	LC	Sch-IV
55	Black drongo	R	Inc/Car/	Com	LC	Sch-IV
56	Whitebellied drongo	R/LM	Inc	UnCom	LC	Sch-IV
57	Paddyfield pipit	R	Inc	Com	LC	Sch-IV
58	Grey wagtail	WV/LM	Inc	UnCom	LC	Sch-IV
59	Large pied wagtail	R/ WV	Inc/Moll/Se	UnCom	LC	Sch-IV
60	Brown shrike	R	Inc	UnCom	LC	Sch-IV
61	Long tailed shrike	R	Inc	UnCom	LC	Sch-IV
62	Baya weaver bird	R/LM	Gra/Se/Inc	Com	LC	Sch-IV
63	Little cormorant	R/LM	Pis/Cru	Com	LC	Sch-IV
64	Snake bird/ Darter	R/LM	Pis	R	LC	Sch-IV
65	Little grebe	R/LM	Pis	R	LC	Sch-IV

A. Distribution Status: Br.V- Breeding Visitors, LM - Local Migrant, R - Resident, WV - Winter Visitor

B. Food habits: Pis – Piscivorous, Ins – Insectivorous, Gra – Grainivorous, Veg – Vegetarian, Aqu.inc Aquatic Insects, Aqu.Veg - Aquatic Vegetation, Cru – Crustaceans, Moll – Molluscs

C. Abundance: Com – Common, R – Rare, UnCom - Un Common, SC – Scarce

W (P) A: 1972 updated up to 2010. Protected birds listed in Schedule-I and IV of the Wildlife Act and Schedule - IV refer to genera, many of which have several species. Many birds are legally protected. Wildlife (Protection) Act - 1972: Schedule - I, Schedule- IV, Schedule -V

D. IUCN Status (2019-2) LC: Least Concern, VU: Vulnerable, NT: Near Threatened

Table 3: Avifaunal percentage composition in different Orders during the study period from June 2015- May 2018

Orders	2015-16 (%)	2016-17 (%)	2017-18 (%)
Anseriformes	5.91	5.90	5.12
Ciconiiformes	64.55	67.00	67.64
Charadriiformes	10.95	10.06	9.15
Coraciiformes	0.05	0.02	0.04
Gruiformes	9.52	9.21	9.64
Passeriformes	4.97	4.41	5.24
Pelecaniformes	3.14	2.79	2.064
Podicipediformes	0.90	0.59	0.71

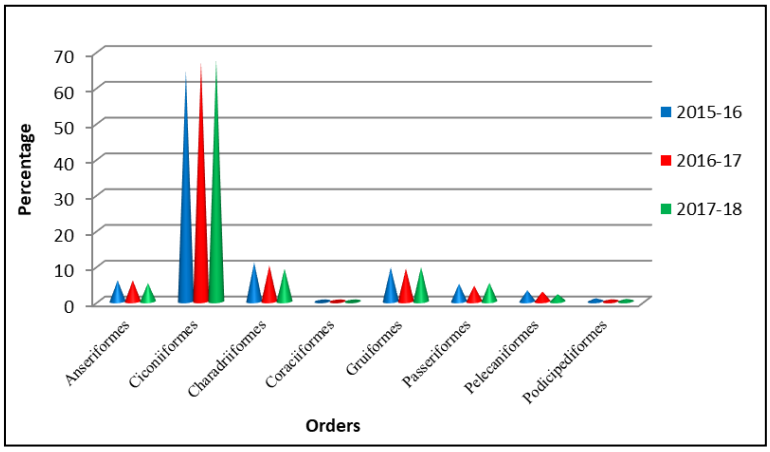

Fig 1: Avifaunal percentage composition from 2015- 2018

Table 4: Avifaunal abundance at Kondakarla Freshwater Lake

Abundance	No. of species	% of species composition
Com - Common	39	60.00
Un Com - Un Common	21	32.31
R – Rare	05	07.69

Table 5: Avifaunal IUCN (2019-2) and W (P) A status – 1972

IUCN Status (2019-2)	**Red List**	**No. of species**	**% of species**
	Least Concern (LC)	58	89.23
	Near Threatened (NT)	06	09.23
	Vulnerable (VU)	01	01.54
W(P)A status – 1972	Category	No. of species	% of species
	Schedule - IV	63	96.92
	Schedule- I	01	01.54
	DD	01	01.54

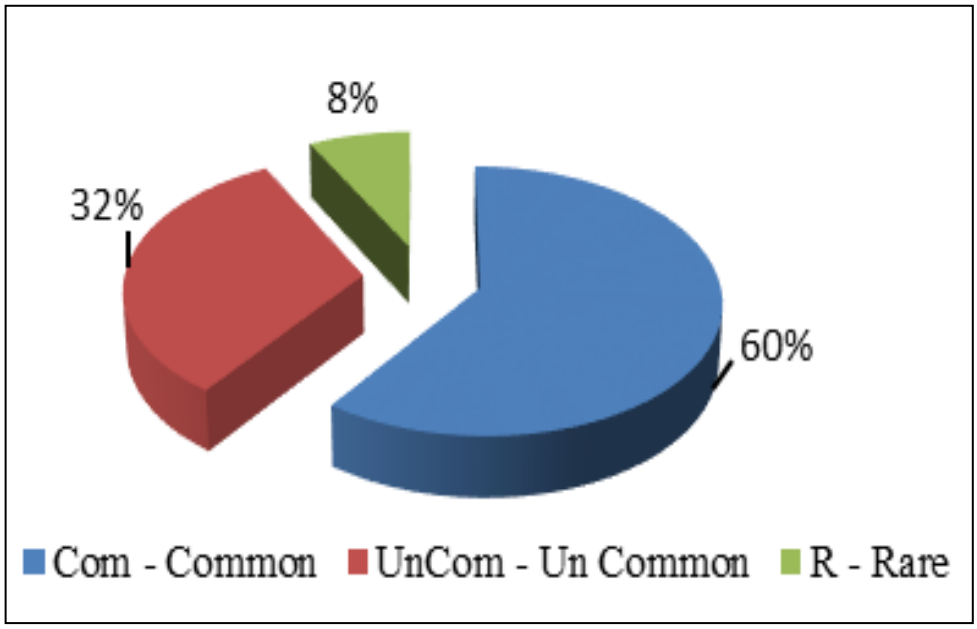

Fig 2: Avifaunal abundance

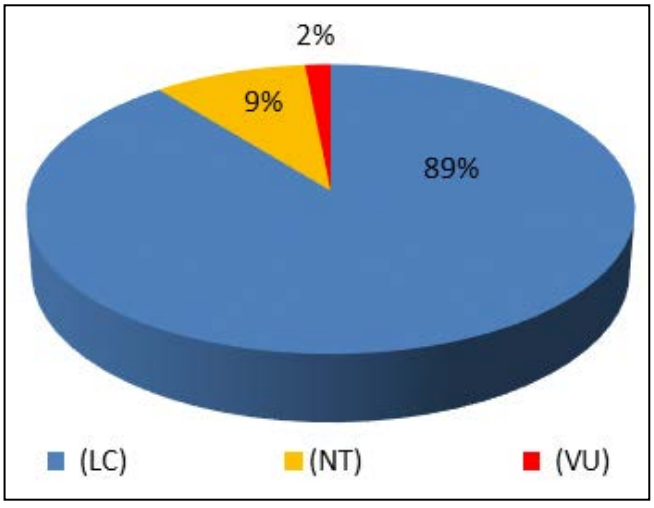

Fig 3: Avifaunal IUCN (2019-2) staus

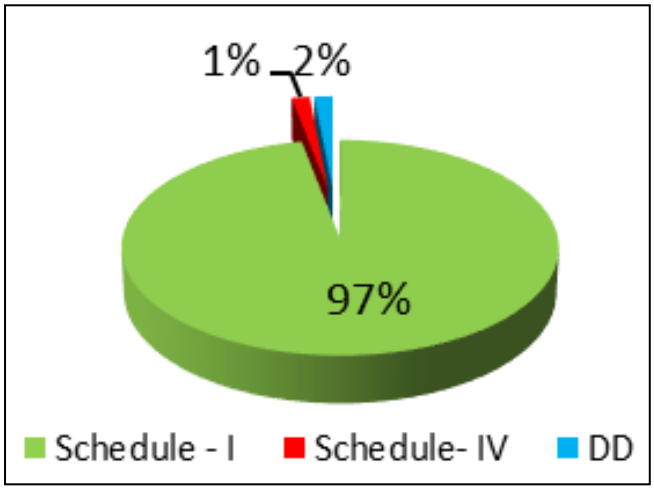

Fig 4: Avifaunal W (P) A status 1972

Table 6: Birds population diversity index average from 2015-2018

	Monsoon				**Post monsoon**				**Pre monsoon**			
Diversity	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**
Species richness	39.00	41.00	43.00	45.00	50.00	54.00	52.00	49.00	46.00	44.67	41.33	34.33
H	1.47	1.55	1.6	1.7	2.00	2.31	2.17	2.02	1.78	1.62	1.51	1.36
ln(S)	3.66	3.71	3.76	3.80	3.91	3.99	3.95	11.67	3.83	3.78	3.72	3.54
Evenness E	0.40	0.42	0.42	0.45	0.51	0.58	0.55	0.52	0.46	0.43	0.41	0.39

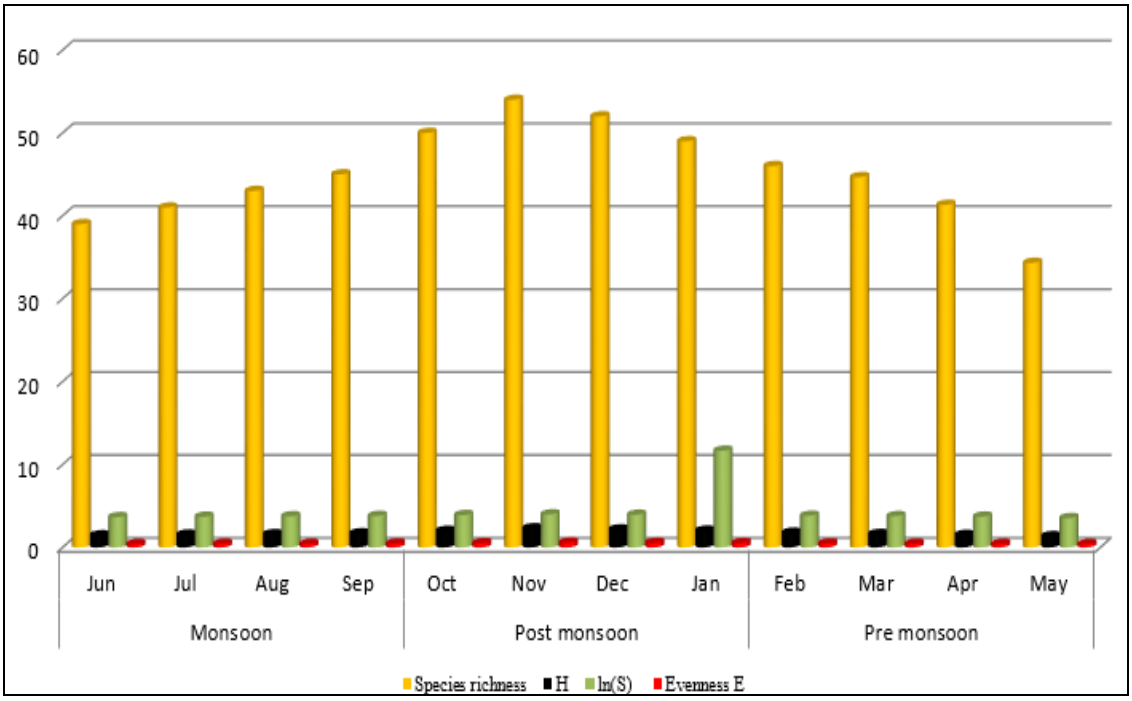

Fig 5: Birds population average diversity index from 2015-2018

Table: 7: Average seasonal population diversity index 2017-2018

Seasons	Species richness	H	Maximum diversity possible ln(S)	Evenness E
pre-monsoon (Summer)	38.75	1.42	3.65	0.39
Monsoon (Rainy)	39.00	1.42	3.66	0.39
post-monsoon (Winter)	48.00	1.85	3.87	0.48
Average	41.92	1.56	3.73	0.42

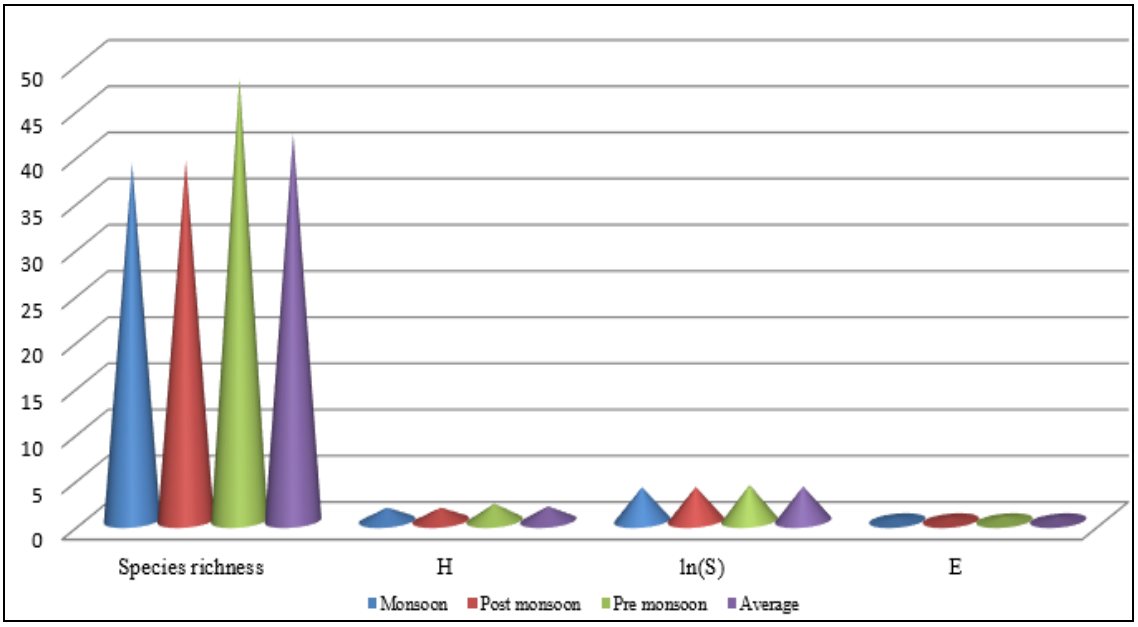

Fig 6: Avifunal average seasonal population diversity index 2017-2018

Discussion

In the present study 65 species of birds belonging to 8 orders, 21 families and 45 genera were recorded during the study period from June 2015 to May 2018 at Kondakarla Freshwater Lake. Jagatheeswari (2014) [29] documented a total of 68 species of Avifauna noted during the survey period, its belonging to 31 Families were noted among these, 35 species of birds are aquatic habitats and 33 species of birds were terrestrial habitats at Kondakarla lake. The similar observation were recorded by various investigators like Tirumala Tulasi *et al*., (2017) [44] reported104 species of birds belonging to 29 families and 11 orders were recorded Tatipudi reservoir. In this study recorded species out of 65, *Ardeidae* was dominant with 11 which contribute to 16.92% indicating the wetland moderately supports shorebirds. Bharatha Lakshmi *et al* (2001) [9] observed 120 number of terrestrial and aquatic avifauna with 32 families recorded at Kondakarla Lake. Rathore and Sharma (1999) [37] explained

Anatidae to be dominating family with 12 species in Sarsai Nawar in UP. Sekhar, Basavarajappa (2006) [6] described 27 species of water birds belonging to 13 families in the agro ecosystem of Maidan area of Karnataka which provided congenial habitat for the survival of water birds. Jagadeswari (2016) mentioned a total of 68 species of birds during the survey belongs to 31 Familes were noted. Among these 68 species of birds, 35 species of birds are aquatic habitats and 33 species of birds were terrestrial. Geofrey *et al*., (2013) [20] observed that the species diversity and abundance of Avifauna in and around Hombolo Wetland. Family Ploceidae had the highest 9 number of bird species followed by Charadriidae. The similar observations were reported by Bharata Lakshmi and Rao, 2003 [8]. Ishwara Bhat *et al*., 2009 [8]. Harisha *et al*., 2011 [11]. Hai, 2012 [24].

The similar observations were reported by various investigators on avifaunal populations in India and other countries (Medhi1 and Suraj Sharma, 2017) [36]. Bellrose and Trudeau (1988) [7] observed the wetlands and their relationship to migrating on winter populations of waterfowls. Aparna and Raja Sekhar (2016) [4] observed that the wetland resident category in highest dominance (62.7%) associated to these habitats most of the time for feeding, nesting and shelter.

Kondakarla Lake plays an important role in the annual cycle of the migratory and non-migratory birds and serves as wintering ground for the migrant species and breeding grounds for several resident birds. Breeding residents responded to annual measures of energy availability while breeding migrants and the winter assemblage responded more strongly to seasonal measures. (Scott and Pool, (1989) [41]. The migratory birds are mostly seen in large flocks or small parties and in mixed flocks around Kondakarla Lake. The study focused on the population characteristics of the dominant birds over a period of three years. The highest species diversity was observed during the post monsoon wet period. The large group of water birds consists mainly of ducks, diving birds like Grebes, Rails, Coots and Moorhens, other birds with aquatic life style and a variety of ducks and waders are visit to the freshwater lake. The population of family Anatidae was the maximum among the winter migrants. The rare and endangered species of are now threatened throughout Europe and Asia Birdlife International, (2001) [14, 15]. Wading birds include Avocets, Curlews, Godwits, Plovers, Sandpipers, Snipes, Lapwings, Shanks, Stilts, Stints, etc. The long legged birds that wade in shallow waters include Herons, Storks, Ibises, Bitterns and Spoonbills. The lake is frequented by the wetland dependent birds which include Kingfishers, Swallows, and Wagtails etc. The population of many species has declined alarmingly. Extremely rare species and rare winter visitors (Spoon bills, Adjutant storks, etc., White Ibis, Black winged Stilts, Glossy Ibis, Cormorants, Herons, variety of Ducks, Variety of Waders along with other miscellaneous groups. Sand Pipers, Lapwings, Avocets, Curlews, Whimbrels, Reef herons, Jacanas, Water cocks, Water hens are reduced due to environmental conditions. Depletion of bird diversity and population can be ascribed to the shrinkage of habitat and various threats in the lake which is used to visit Kondakarla Lake slowly disappeared and the diversity as well as population size have reduced which is observed during the study period.

According to IUCN (2019.2) [28], fifty eight species were contribute to highest 89.23% are least concerned (LC), six species contribute to 09.23% are near threaten (NT), the lowest one species is vulnerable 1.54% (VU) in the total avifauna. Islam and Rahmani (2004) [27] represented threatened birds of India as per IUCN 1990, IUCN 2010, Anon (1974) [3]. The present investigation concentrated on Wildlife Protection Act revealed that 63 species were highest represented to 96.92% Schedule- IV category, one species were represented to each with 1.54% Schedule- I category and data deficient was observed most of the literature (Arora, 2003) [5]. Harisha (2016) [26] reported Black-headed Ibis, Darter, Black-tailed and River terns have a protected status under the schedule IV of Indian Wildlife Protection Act, 1972.

Conclusion

The avifauna population showed significant variations at every successive year from 2015 to 2018. The biodiversity indices were also exhibit down trend of migratory bird species at year wise successive period from 2015 to 2018.

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