Biological Forum – An International Journal **6**(2): 62-76(2014)

ISSN No. (Print): 0975-1130
ISSN No. (Online): 2249-3239

Diversity, Abundance and Variation of Water Birds at Kolleru Wetland in Andhra Pradesh

V. Vasudeva Rao, R. Sravan Kumar, G. Surender and B. Laxmi Narayana
All India Network Project on Agricultural Ornithology,
Acharya N.G. Ranga Agricultural University, Rajendranagar, Hyderabad, India

(Corresponding author: V. Vasudeva Rao)
(Received 08 July, 2014, Accepted 01 September, 2014)

ABSTRACT: The present paper deals with diversity, abundance and variations of water birds at Kolleru wetland. The study was carried out for a period of five years from March 2007 to July, 2012. A total of 232 species of birds belonging to 62 families and 115 genera were recorded. Among which 101 species are water birds, 133 species are terrestrial birds of which 83 species recorded as migratory birds and 14 species as local migrants. The mean Water bird population varies from 258.36 ± 1420.14 to 95.10 ± 500.28 whereas terrestrial bird populations 2.47 ± 5.72 to 1.69 ± 3.73 which is significantly very low. The maximum numbers of 123 species were recorded in the month of March 2007-08 and the minimum number of species about 30 was recorded in the month of July 2010-11. The diversity index is fluctuating with an increasing and decreasing sequence ranging from 1 to 5.3 in overall bird populations and 0.5 to 2.3 in waterfowl populations. Likewise, the diversity and evenness showed variations between the bird richness and density. The lake is facing several threats such as expansion of aquaculture and agriculture in waterfowl areas and other indirect factors include deterioration of water quality, vegetational changes, and disturbance-through boat movements, cattle grazing. Based on the long term studies, proposed conservation measures for sustainability of the waterfowl at Kolleru Lake.

Keywords: Wetland birds, Kolleru, Andhra Pradesh.

INTRODUCTION

One of the most significant bird sanctuaries in India exists at Kolleru, the largest fresh water lake in Andhra Pradesh with a water spread area of 901 sq.km. Geographically the area lies between 80°5' to 81°2Q'E and 16°32' to 16°57'N (Fig. 1). The lake is connected to the Bay of Bengal through a narrow tidal creek known as 'Upputeru' and is fed by 2 rivers, 15 irrigation channels and 15 drains from Krishna and Godavari irrigation system.

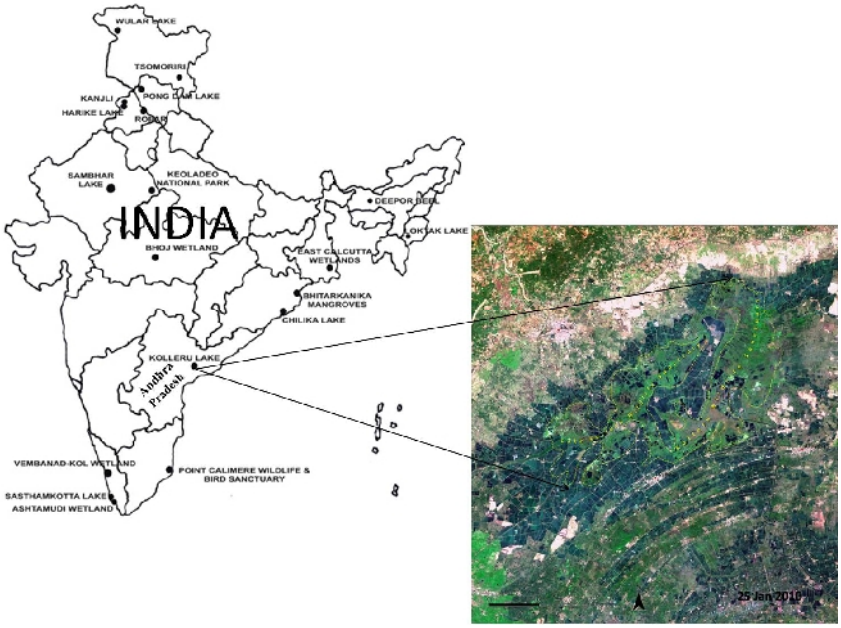

Fig. 1. Geographical location of Kolleru Lake (Source: Crop aqua culture overwhelms Lake Kolleru A.P. India UNEP).

Thus, the lake swells up during South West monsoon period from August to December. In the summer period, the water spread shrinks to less than 26 sq km of area. This wetland habitat harbours a variety of flora and fauna (Neelakantan 1949), and was declared 'a protected area' for Pelicans during 1962. Since 1972, the famed pelicanary was abandoned due to ecological disturbance imposed by man (Nagulu & Ramana Rao 1983). Now in the present study, the pelican was reported back from 2008 onwards and started nesting in artificial platforms successfully in all the years of study. In spite of several efforts the lake is facing several threats. These include, the roads, bridges, foreshore farm lots and human habitations which break up the organic continuity of the lake. The sewage influx, industrial effluents and pesticide residues seriously affect the lake environment. The lake is totally covered with exotic floating weeds like *Ipomoea aquatica* and *Salvinia* sp. and *Eichltomia* carpeting huge tracts of water surface. Cyclone visitations and consequent flood are common.

Though the area is declared as a sanctuary, large scale trapping of birds is commonly observed. The present paper explains the diversity, abundance and variation of water birds and various problems faced by Kolleru Wetland and discusses some important conservation measures.

MATERIAL AND METHODS

The study area was confined to a limited part of the lake of about 4 sq km. Observations were conducted in this area at weekly intervals between March 2007 to July, 2012. The field notes on major bird fauna were mainly taken during forenoon between 7 A.M. to 11 A.M. by using 10 x 50 binoculars.

At each sampling station, observations were made on population estimations, predators, vegetation changes, land-use patterns and man-made effects like poaching and water level changes. The mean monthly variations were also calculated by employing mean, standard deviation, range and coefficient of variations (Jarvinan and Varsanan 1976). The species diversity index was calculated according to Shannon & Weiner Index.

SD: - $\sum$ log pi x pi

Where pi is the relative abundance of i^{th} species

Equally common species: Diversity / log s

Where, S is number of individuals

Three distinct major habitats are identified in the study area of Komatilanka. These are: (1) Open lake is covered with *Ipomoea aquatica, Eichhomia* spp. and by a smaller extent *Typha* and *Phragmitis karka.* Water depth varies from few inches to 5 feet during floods; (2) bunded and enclosed fish tank area of about 480 ha generally filled with water and kept free of weeds; (3) there is one bed village with population of about 2500. The human interference in study area is limited to footpath on the tank and bunds connecting villages.

RESULTS AND DISCUSSION

In the present study a total of 232 species of birds belonging to 62 families and 115 genera recorded in a period of five years against the earlier sporadic listing of 222 species of birds by Azeez *et al* (2011), 60species of birds by Balakrishna (1984) and 196 species of birds by Anjaneyulu (1992). The status of each bird species is determined in relation to the habitat, migration and distribution based on systematic field survey by using standard survey techniques in main core area and also in other areas in various habitats (Table 1).

Table 1. Check list of Birds recorded at Kolleru lake, Andhra Pradesh.

Sl. no	Common name	Scientific name	Abundance	Status
Order:	**Podicipediformes**			
Family:	**Podicipedidae**			
1.	Great crested grebe	*Podiceps cristatus*	R	WM
2.	Little grebe	*Tachybaptus ruficollis*	A	RE/B
Order:	**Pelecaniformes**			
Family:	**Pelicanidae**			
3.	Grey pelican	*Pelicanus philippensis*	A	RE/B/LM
4.	Indian shag (Indian cormorant)	*Phalacrocorax fuscicollis*	C	RE/B
5.	Great cormorant	*Phalacrocorax carbo*	C	WM
6.	Little cormorant	*Phalacrocorax niger*	C	Re/Br
7.	Darter (Oriental darter)	*Anhinga melanogaster*	C	WM
Order:	**Ciconiiformes**			
Family:	**Ardeidae**			
8.	Grey heron	*Ardea cinerea*	C	RE/B
9.	Purple heron	*Ardea purpurea*	C	RE/B
10.	Large egret	*Casmerodius albus*	C	RE/B
11.	Indian pond-heron	*Ardeola grayii*	C	RE/B

12.	Eastern cattle egret (Cattle egret)	*Bubulcus ibis*	A	RE/B
13.	Median egret	*Mesophoyx intermedia*	C	RE/B
14.	Little egret	*Egretta garzetta*	C	RE/B
15.	Indian reef heron	*Egretta gularis*	C	RE/B
16.	Black-crowned night-heron	*Nycticorax nycticorax*	C	RE/B
17.	Little bittern	*Ixobrychus minutus*	C	RE/B
18.	Chestnut bittern (Cinnamon bittern)	*Ixobrychus cinnamomeus*	C	RE/B
19.	Yellow bittern	*Ixobrychus sinensis*	C	RE/B
20.	Black bittern	*Dupetor flavicollis*	C	RE/B
Family:	**Ciconiidae**			
21.	Painted stork	*Mycteria leucocephala*	C	RE/B
22.	Asian open-billed stork	*Anastomus oscitans*	A	RE/B
23.	Lesser adjudant	*Leptoptilos javanicus*	VR	WM
Family:	**Threskiornithidae**			
24.	Black-headed ibis (Asian white ibis)	*Threskiornis melanocephalus*	C	RE/B
25.	Glossy ibis	*Plegadis falcinellus*	C	WM
26.	Eurasian spoonbill	*Platalea leucorodia*	C	WM
27.	Indian black ibis (Black ibis)	*Pseudibis papillosa*	C	RE/B
Order:	**Phoenicopteriformes**			
Family:	**Phoenicopteridae**			
28.	Greater flamingo	*Phoenicopterus roseus*	R	WM
Order:	**Anseriformes**			
Family:	**Anatidae**			
29.	Bar-headed goose	*Anser indicus*	C	WM
30.	Grey lag goose	*Anser anser*	VR	WM
31.	Lesser whistling-duck	*Dendrocygna javanica*	C	RE/B
32.	Large whistling duck	*Dendrocygna bicolor*	C/R	WM
33.	Ruddy shelduck	*Tadorna ferruginea*	C	WM
34.	Northern pintail	*Anas acuta*	C	WM
35.	Common teal	*Anas crecca*	C	WM
36.	Indian spot-billed duck (Spot-billed duck)	*Anas poecilorhyncha*	C	RE/B
37.	Gadwall	*Anas strepera*	C	WM
38.	Eurasian wigeon	*Anas penelope*	C	WM
39.	Garganey	*Anas querquedula*	C	WM
40.	Northern shoveller	*Anas clypeata*	C	WM
41.	Mallard	*Anas platyrhynchos*	C	WM
42.	Red-crested pochard	*Rhodonessa rufina*	C	WM
43.	Common pochard	*Aythya ferina*	C	WM
44.	Ferruginous pochard	*Aythya nyroca*	O	WM
45.	Tufted duck (Tufted pochard)	*Aythya fuligula*	C	WM
46.	Scaup duck	*Aythya marila*	O	WM
47.	Cotton teal (Cotton pygmy-goose)	*Nettapus coromandelianus*	C	WM

48.	Comb duck	*Sarkidiornis melanotos*	C	WM
Order:	**Falconiformes**			
Family:	**Accipitridae**			
49.	Black-winged kite (Black-shouldered kite)	*Elanus caeruleus*	C	RE/B
50.	Brahminy kite	*Haliastur indus*	C	RE/B
Order:	**Acciptriformes**			
Family:	**Accipitridae**			
51.	Black kite	*Milvus migrans*	C	RE
52.	Besra sparrowhawk	*Accipiter virgatus*	C	RE/B
53.	Shikra	*Accipiter badius*	C	RE
54.	Long-legged buzzard	*Buteo rufinus*	C	RE/B
55.	White-eyed buzzard	*Butastur teesa*	C	RE/B
56.	Indian spotted eagle (Lesser spotted eagle)	*Aquila pomarina*	C	RE/B
57.	Indian long billed vulture	*Gyps indicus*	R	RE
58.	White backed vulture	*Gyps bengalensis*	A	RE
59.	Scavenger vulture	*Neophron perenopterus*	A	RE
60.	Crested serpent-eagle	*Spilornis cheela*	C	RE/B
61.	Short-toed eagle (Short-toed snake-eagle)	*Circaetus gallicus*	C	RE/B
62.	Tawny eagle	*Aquila rapax*	C	RE
63.	Osprey	*Pandion haliaetus*	C	WM
64.	Pallid harrier	*Circus macrourus*	C	B/LM
65.	Pied harrier	*Circus melanoleucos*	C	B/LM
66.	Hen harrier	*Circus cyaneus*	C	RE/B
67.	Western marsh harrier (Eurasian marsh harrier)	*Circus aeruginosus*	C	RE/B
Family:	**Falconidae**			
68.	Common kestrel	*Falco tinnunculus*	C	RE/B
69.	Red-headed falcon	*Falco chicquera*	O	WM
70.	Laggar falcon	*Falco jugger*	O	WM
Order:	**Galliformes**			
Family:	**Phasianidae**			
71.	Grey francolin	*Francolinus pondicerianus*	C	RE/B
72.	Rain quail	*Coturnix coromandelica*	C	RE/B
73.	Jungle bush-quail	*Perdicula asiatica*	C	RE/B
74.	Indian peafowl	*Pavo cristatus*	C	RE/B
Order:	**Gruiformes**			
Family:	**Rallidae**			
75.	Slaty-breasted rail	*Gallirallus striatus*	C	RE
76.	European water rail (Water rail)	*Rallus aquaticus*	C	RE/B
77.	Banded crake	*Rallina eurizonoides*	R	LM
78.	Little crake	*Porzana parva*	C	RE
79.	Spotted crake	*Porzana porzana*	O	WM
80.	Brown crake	*Amaurornis akool*	R	RE
81.	White-breasted waterhen	*Amaurornis phoenicurus*	C	RE/B

82.	Watercock	*Gallicrex cinerea*	C	RE/B
83.	Purple swamphen	*Porphyrio porphyrio*	C	RE/B
84.	Common moorhen	*Gallinula chloropus*	C	RE/B
85.	Eurasian coot (Common coot)	*Fulica atra*	C	RE/B
Family:	**Jacanidae**			
86.	Bronze-winged jacana	*Metopidius indicus*	C	RE/B
87.	Pheasant-tailed jacana	*Hydrophasianus chirurgus*	C	RE/B
Order:	**Charadriiformes**			
Family:	**Rostratulidae**			
88.	Greater painted-snipe	*Rostratula benghalensis*	C	WM
Family:	**Recurvirostridae**			
89.	Black-winged stilt	*Himantopus himantopus*	C	LM
90.	Pied avocet	*Recurvirostra avosetta*	C	WM
Family:	**Glareolidae**			
91.	Collared pratincole	*Glareola ptatincolea*	C	WM
92.	Small pratincole	*Glareola lactea*	C	WM
Family:	**Charadriidae**			
93.	Red-wattled lapwing	*Vanellus indicus*	C	RE/B
94.	Yellow-wattled lapwing	*Vanellus malarbaricus*	C	RE/B
95.	Pacific golden plover	*Pluvialis fulva*	C	WM
96.	Greater sand plover	*Charadrius leschenaultii*	C	WM
97.	Lesser sand plover	*Charadrius mongolus*	C	WM
98.	Common ringed plover	*Charadrius hiaticula*	C	WM
99.	Little ringed plover	*Charadrius dubius*	C	WM
100.	Kentish plover	*Charadrius alexandrinus*	C	WM
Family:	**Scolopacidae**			
101.	Eurasian curlew	*Numenius arquata*	C	WM
102.	Whimbrel	*Numenius phaeopus*	C	WM
103.	Western black-tailed godwit (Black-tailed godwit)	*Limosa limosa*	C	WM
104.	Common redshank	*Tringa totanus*	C	WM
105.	Marsh sandpiper	*Tringa stagnatilis*	C	WM
106.	Common greenshank	*Tringa nebularia*	C	WM
107.	Wood sandpiper	*Tringa glareola*	C	WM
108.	Green sandpiper	*Tringa ochropus*	C	WM
109.	Common sandpiper	*Actitis hypoleucos*	C	WM
110.	Wood snipe	*Gallinago nemoricola*	C	WM
111.	Pintail snipe	*Gallinago stenura*	R	WM
112.	Common snipe (Fan-tail snipe)	*Gallinago gallinago*	C	WM
113.	Great knot	*Calidris tenuirostris*	C	WM
114.	Little stint	*Calidris minuta*	C	WM
115.	Ruff (m) and reeve (f)	*Philomachus pugnax*	C	WM
116.	Red-necked phalarope	*Phalaropus lobatus*	C	WM

117.	Herring gull	*Larus argentatus*	C	LM
118.	Brown-headed gull	*Larus brunnicephalus*	C	WM
119.	Common black-headed gull	*Larus ridibundus*	C	WM
120.	River tern	*Sterna aurantia*	C	RE
121.	Common tern	*Sterna hirundo*	C	RE
122.	Little tern	*Sterna albifrons*	C	LM
Family:	**Sternidae**			
123.	Whiskered tern	*Chlidonias hybridus*	C	WM
124.	White winged black tern	*Chlidonias leucopterus*	R	LM
Order:	**Columbiformes**			
Family:	**Columbidae**			
125.	Blue rock pigeon	*Columba livia*	C	RE
126.	Eurasian collared-dove	*Streptopelia decaocto*	C	RE/B
127.	Red collared-dove	*Streptopelia tranquebarica*	C	RE/B
128.	Spotted dove	*Streptopelia chinensis*	C	RE/B
129.	Little brown dove	*Streptopelia senegalensis*	C	RE/B
Order:	**Psittaciformes**			
Family:	**Psittacidae**			
130.	Plum-headed parakeet	*Psittacula cyanocephala*	C	WM
131.	Rose-ringed parakeet	*Psittacula krameri*	C	R/B
132.	Alexandrine parakeet	*Psittacula eupatria*	C	R/B
Order:	**Cuculiformes**			
Family:	**Cuculidae**			
133.	Common hawk-cuckoo (Indian hawk-cuckoo)	*Hierococcyx varius*	C	RE
134.	Pied crested cuckoo	*Clamator jacobinus*	C	WM
135.	Indian cuckoo	*Cuculus micropterus*	C	RE/B
136.	Asian koel	*Eudynamys scolopacea*	C	RE/B
137.	Greater coucal	*Centropus sinensis*	C	RE/B
138.	Blue-faced malkoha	*Phaenicophaeus viridirostris*	C	RE
139.	Sirkeer malkoha	*Phaenicophaeus leschenaultii*	C	RE
Order:	**Strigiformes**			
Family:	**Strigidae**			
140.	Common barn-owl	*Tyto alba*	C	RE/B
141.	Spotted owlet	*Athene brama*	C	RE/B
142.	Brown fish-owl	*Ketupa zeylonensis*	C	RE/B
143.	Eurasian eagle-owl	*Bubo bubo*	C	WM
Order:	**Apodiformes**			
Family:	**Apodidae**			
144.	Asian palm-swift	*Cypsiurus balasiensis*	C	RE/B
145.	Little swift (House swift)	*Apus affinis*	C	RE/B
146.	Alpine swift	*Tachymarptis melba*	C	LM
Order:	**Coraciiformes**			
Family:	**Alcedinidae**			
147.	Lesser pied kingfisher	*Ceryle rudis*	C	RE/B
148.	Common kingfisher	*Alcedo atthis*	C	RE/B
149.	White-throated kingfisher	*Halcyon smyrnensis*	C	RE/B

Family:	**Meropidae**			
150.	Chestnut-headed bee-eater	*Merops leschenaulti*	C	WM
151.	Blue-tailed bee-eater	*Merops philippinus*	C	WM
152.	Little green bee-eater (Green bee-eater)	*Merops orientalis*	C	RE/B
Family:	**Bucerotidae**			
153.	Indian grey hornbill	*Ocyceros birostris*	C	RE/B
Family:	**Coraciidae**			
154.	Indian roller	*Coracias benghalensis benghalensis*	C	RE/B
Family:	**Upupidae**			
155.	Common hoopoe	*Upupa epops epops*	C	RE/B
Order:	**Piciformes**			
Family:	**Ramphastidae**			
156.	Brown-headed barbet	*Megalaima zeylanica*	C	RE/B
157.	Coppersmith barbet	*Megalaima haemacephala*	C	RE/B
Family:	**Picida**			
158.	Black-rumped flameback (Back-rumped flamebacked woodpecker)	*Dinopium benghalense*	C	RE/B
Order:	**Passeriformes**			
Family:	**Alaudidae**			
159.	Indian bushlark (Redwinged bush-lark)	*Mirafra erythroptera*	C	RE/B
160.	Ashy-crowned finch-lark (Ashy-crowned sparrow-lark)	*Eremopterix grisea*	C	RE/B
161.	Rufous-tailed lark	*Ammomanes phoenicurus*	C	RE/B
162.	Greater short-toed lark	*Calandrella brachydactyla longipennis*	C	WM
163.	Crested lark	*Galerida cristata*	C	WM
164.	Sky lark	*Aluda arvensis*	C	WM
Family:	**Campephagidae**			
165.	Small minivet	*Pericrocotus cinnamomeus*	C	RE/B
166.	Orange minivet (scarlet minivet)	*Pericrocotus flammeus*	C	RE/B
Family:	**Aegithinidae**			
167.	Common iora	*Aegithina tiphia*	C	RE/B
Family:	**Chloropseidae**			
168.	Gold-fronted leafbird	*Chloropsis aurifrons*	C	RE/B
169.	Blue-winged leafbird (Jerdon's leafbird)	*Chloropsis cochinchinensis*	C	RE/B
Family:	**Hirundinidae**			
170.	Dusky crag-martin	*Hirundo concolor*	C	RE/B
171.	Red-rumped swallow	*Hirundo daurica*	C	RE/B
172.	Wire-tailed swallow	*Hirundo smithii*	C	WM
173.	Pacific swallow (House swallow)	*Hirundo tahitica*	C	RE
174.	Indian cliff swallow (Streak-throated swallow)	*Hirundo fluvicola*	R	WM

Family:	**Laniidae**			
175.	Bay-backed shrike	*Lanius vittatus*	C	RE/B
176.	Rufous-backed shrike	*Lanius schach*	C	RE/B
177.	Grey shrike	*Lanius excubitor*	C	RE/B
178.	Brown shrike	*Lanius cristatus cristatus*	C	RE/B
Family:	**Oriolidae**			
179.	European golden oriole (Eurasian golden oriole)	*Oriolus oriolus*	C	RE/B
180.	Black-hooded oriole	*Oriolus xanthornus*	C	WM
Family:	**Dicruridae**			
181.	Black drongo	*Dicrurus macrocercus*	C	RE/B
182.	White-bellied drongo	*Dicrurus caerulescens*	C	WM
Family:	**Artamidae**			
183.	Ashy wood swallow (Ashy swallow shrike)	*Artamus fuscus*	C	WM
Family:	**Sturnidae**			
184.	Grey headed starling	*Sturnia malabarica*	C	WM
185.	Rosy starling	*Sturnus roseus*	C	WM
186.	Asian pied starling	*Sturnus contra*	C	RE/B
187.	Common myna	*Acridotheres tristis*	C	RE/B
188.	Brahminy starling	*Sturnus pagodarum*	C	RE/B
Family:	**Corvidae**			
189.	Rufous treepie	*Dendrocitta vagabunda*	C	RE/B
190.	House crow	*Corvus splendens*	C	RE/B
191.	Indian jungle crow (Jungle crow)	*Corvus macrorhynchos culminatus*	C	RE/B
Family:	**Tephrodornithidae**			
192.	Common wood shrike	*Tephrodornis pondicerianus*	C	WM
Family:	**Campephagidae**			
193.	Large cuckoo shrike	*Coracina novaehollandiae*	O	WM
Family:	**Pycnonotidae**			
194.	Red-vented bulbul	*Pycnonotus cafer*	C	RE/B
Family:	**Pellorneidae**			
195.	Small wren babbler	*Napothera epilepidota*	R	LM
Family:	**Timaliidae**			
196.	Rufousbellied babbler (Tawny-bellied babbler)	*Dumpetia hyperythra*		
197.	Large grey babbler	*Turdoides malcolmi*	C	RE/B
Family:	**Leiothrichidae**			
198.	Streaked laughing thrush	*Trochalopteron lineatum*	C	RE
Family:	**Muscicapidae**			
199.	Whitebellied blue flycatcher	*Cyornis pallipes*	C	RE
Family:	**Monarchidae**			
200.	Asian paradise flycatcher	*Terpsiphone paradisi*	C	RE/B
Family:	**Sylviidae**			
201.	Common tailorbird	*Orthotomus sutorius*	C	RE/B

Family:	**Cisticolidae**			
202.	Ashy prinia	*Prinia socialis*	C	RE/B
203.	Plain prinia	*Prinia inornata*	C	RE/B
Family:	**Acrocephalidae**			
204.	Indian reed-warbler (Clamorous reed-warbler)	*Acrocephalus stentoreus brunnescens*	C	RE/B
Family:	**Sylviidae**			
205.	Blyth's reed-warbler	*Acrocephalus dumetorum*	C	WM
206.	Thick-billed warbler	*Acrocephalus aedon*	C	RE/B
207.	Paddyfield warbler	*Acrocephalus agricola*	C	RE/B
208.	Rufous fronted wren warbler	*Prinia buchanani*		
209.	Chieffchaff	*Phylloscopus coilybita*		
Family:	**Muscicapidae**			
210.	Blue throat	*Luscinia svecica svecica*	C	WM
211.	Oriental magpie-robin	*Copsychus saularis*	C	RE/B
212.	Common stonechat	*Saxicola torquata*	C	RE/B
213.	Pied bushchat	*Saxicola caprata*	C	RE/B
214.	Indian black robin (Indian robin)	*Saxicoloides fulicata*	C	RE/B
215.	Blue rock-thrush	*Monticola solitarius*	C	RE/B
Family:	**Motacillidae**			
216.	Paddyfield pipit	*Anthus rufulus*	C	RE/B
217.	Forest wagtail	*Dendronanthus indica*	C	WM
218.	White wagtail	*Motacilla alba dukhunensis*	C	WM
219.	Western yellow wagtail (Yellow wagtail)	*Motacilla flava leucocephala*	C	WM
220.	Grey wagtail	*Motacilla cinerea*	C	WM
221.	White-browed wagtail (Large pied wagtail)	*Motacilla maderaspatensis*	C	RE
222.	Yellow headed wagtail	*Motacilla citreola*	C	RE/B
223.	Tickell's flower pecker	*Dicaeus erythrorhynchos*	C	RE/B
Family:	**Nectariniidae**			
224.	Purple-rumped sunbird	*Nectarinia zeylonica*	C	RE/B
225.	Purple sunbird	*Nectarinia asiatica*	C	RE/B
Family:	**Zosteropidae**			
226.	White eye	*Zosterops palpebrosa*	C	RE/B
Family:	**Passeridae**			
227.	House sparrow	*Passer domesticus*	C	RE/B
Family:	**Ploceidae**			
228.	Indian baya weaver (Baya weaver)	*Ploceus philippinus philippinus*	C	RE/B
229.	Streaked weaver	*Ploceus manyar*	C	WM
Family:	**Estrildidae**			
230.	Scaly-breasted munia	*Lonchura punctulata*	C	RE/B
231.	White-rumped munia	*Lonchura striata*	C	RE/B
232.	Rufous bellied munia	*Lonchura kelaarti*	O	WM

Note: C = Common, A = Abundant, O = Occasional, R = Rare, RE = Resident, B = Breeding, WM = Winter Migrant and LM = Local Migrant.

Categorization of species

(*i*) 101 species are water birds, inhabiting the open waters and in the wetland vegetation.

(*ii*) 133 species are terrestrial birds which are observed on the islands, exposed land masses and fish tank bunds either perching or nesting and also on feeding grounds 83 species recorded as migratory birds. These species are seen in this wetland every year only during the months from October to March.

(*iii*) 14 species are classified as local migrants; their local movements are restricted to small distances either for feeding or breeding (Table 2).

(*iv*) 137 species are resident birds which are regularly observed while feeding as well as to be breeding in this wetland.

(*v*) Over 118 species of birds are utilizing the lake for feeding and also for breeding. Out of these, 23 species of water birds are seen in nesting activity.

(*vi*) 27 species are listed as dominant in the lake based on the density. The most dominant species are migratory wild-ducks and one species of Open bill Stork as local migrant. These birds are observed in thousands.

(*vii*) 204 species are common that are observed once in a while

(*viii*) 11 species are rare which are recorded occasionally.

(*ix*) 7species are very rarely observed.

Table 2. Status of Birds recorded at Kolleru lake, Andhra Pradesh.

S. no	Order	No. of families	No. of species	Occurrence				Status			
				C	A	O	R	RE	B	WM	LM
1.	**Podicipediformes**	**1**	2	0	1	0	1	1	1	2	0
2.	**Pelecaniformes**	1	5	4	1	0	0	3	3	2	1
3.	**Ciconiiformes**	**3**	20	17	2	0	1	17	17	3	0
4.	**Phoenicopteriformes**	**1**	1	0	0	1	0	0	0	1	0
5.	**Anseriformes**	**1**	20	17	0	2	1	2	2	18	0
6.	**Falconiformes**	**1**	2	2	0	0	0	2	2	0	0
7.	**Acciptriformes**	**2**	20	15	2	1	1	14	10	2	2
8.	**Galliformes**	**1**	4	4	0	1	0	4	4	1	0
9.	**Gruiformes**	**2**	13	10	0	0	2	11	8	0	1
10.	**Charadriiformes**	**7**	38	34	0	1	1	4	2	30	3
11.	**Columbiformes**	1	5	5	0	1	0	5	3	0	0
12.	**Psittaciformes**	1	3	3	0	0	0	2	2	1	0
13.	**Cuculiformes**	1	7	7	0	0	0	6	3	1	0
14.	**Strigiformes**	1	4	4	0	0	0	3	3	1	0
15.	**Apodiformes**	1	3	3	0	0	0	2	2	0	1
16.	**Coraciiformes**	5	9	9	0	0	0	7	7	2	0
17.	**Piciformes**	2	3	3	0	0	0	3	3	0	0
18.	**Passeriformes**	30	73	67	4	4	0	51	46	19	6
Total		**62**	**232**	**204**	**10**	**11**	**7**	**137**	**118**	**83**	**14**

The estimates of the annual bird population variations were studied from July 2007 to July 2012. The variations of bird populations including terrestrial and aquatic birds are illustrated (Table 3). A significant decrease in bird populations was noticed in recent years. The mean maximum population of 57.7 $\pm$ 327.6 was recorded in the first year 2007-08 and the mean value has been gradually decreased in the consequent years, the mean minimum 38.4 $\pm$ 242.7 was recorded in 2009-10. Further, the populations of water birds were compared with that of terrestrial birds. The mean Water bird population varies from 258.36 $\pm$ 1420.14 to 95.10 $\pm$ 500.28 whereas terrestrial bird populations 2.47 $\pm$ 5.72 to 1.69 $\pm$ 3.73 which is significantly very low. Monthly variations in total bird number as well as species number for total birds and water birds were shown in Fig.2 and 3. The significant increase in the individual number and species number were found to be higher from November to April in all the five years census counts and these numbers were lower from May to September.

The maximum number of 123 species were recorded in the month of March 2007-08 and the minimum number of species about 30 were recorded in the month of July 2010-11, whereas the maximum bird populations varies from 62,277 February, 2007-8 to 147 in August 2008-09. A similar trend of population sequence was seen in the water bird (Fig. 3 and 4).

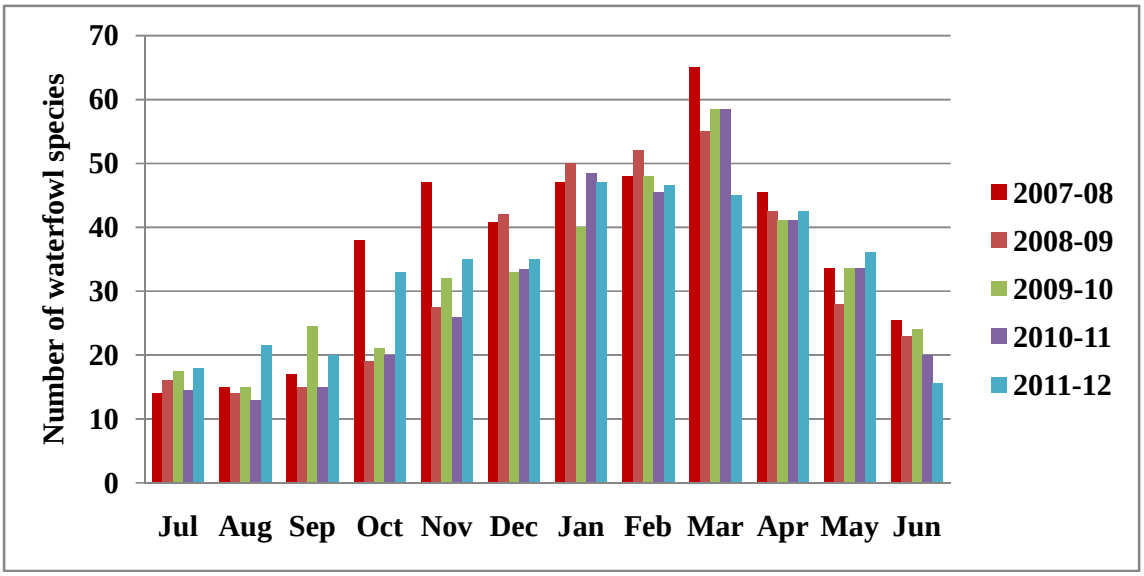

Fig. 2. Variations in total number o f bird species in different months during the study period.

Table 3. Bird species composition at Kolleru lake during the study period.

S.No	Item	2007-08	2008-09	2009-10	2010-11	2011-12
A	**Total Birds**					
	Mean	142.17	91.06	57.7	77.51	61.57
	Sd	1057.4	636.4	372.6	501.48	400.27
	Range	(1-11408)	(1-6110)	(1-4354)	(1-4903)	(1-4085)
	C.V.	8.1	5.95	6.11	5.86	5.87
B	**Water Birds**					
	Mean	258.36	165.39	95010	140.1	111.16
	Sd	1420.4	853.99	500.28	671.9	536.51
	Range	(1-11408)	(1-6110)	(1-4354)	(1-4903)	(1-4085)
	C.V.	6.16	4.72	4.91	4.71	4.64
C	**Terrestrial Birds**					
	Mean	2.47	1.69	1.89	2.24	1.95
	Sd	5.72	3.73	4021	4.64	4.07
	Range	(1-37)	(1-24)	(1-24)	(1-27)	(1-23)
	C.V.	2.36	2.4	2.3	2.33	2.2

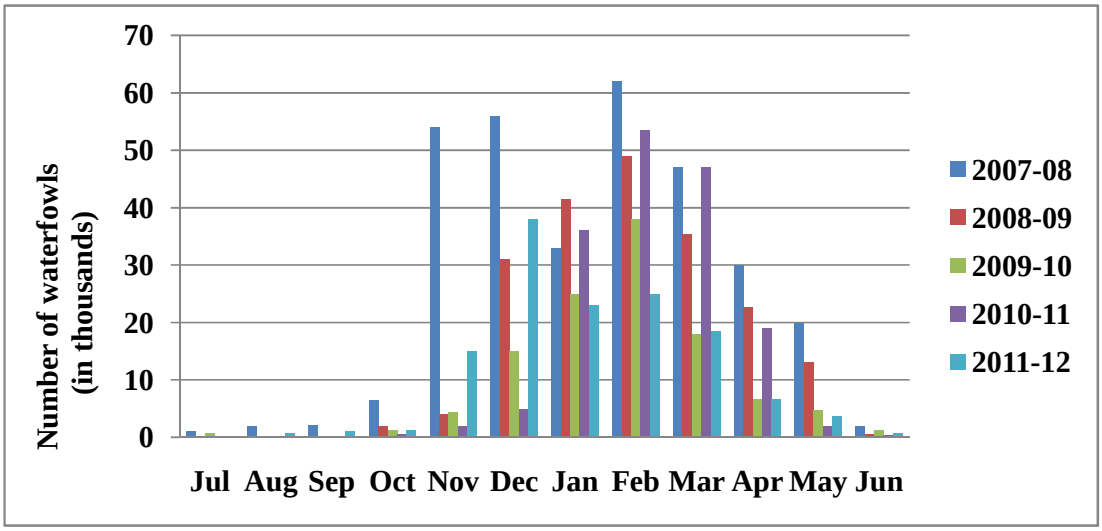

Fig. 3. Absolute number of birds in different months during the study period.

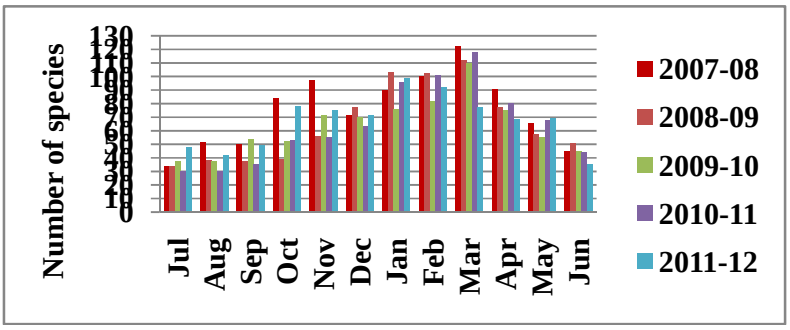

Fig. 4. Variations in total number of waterfowl species in different months during the study period.

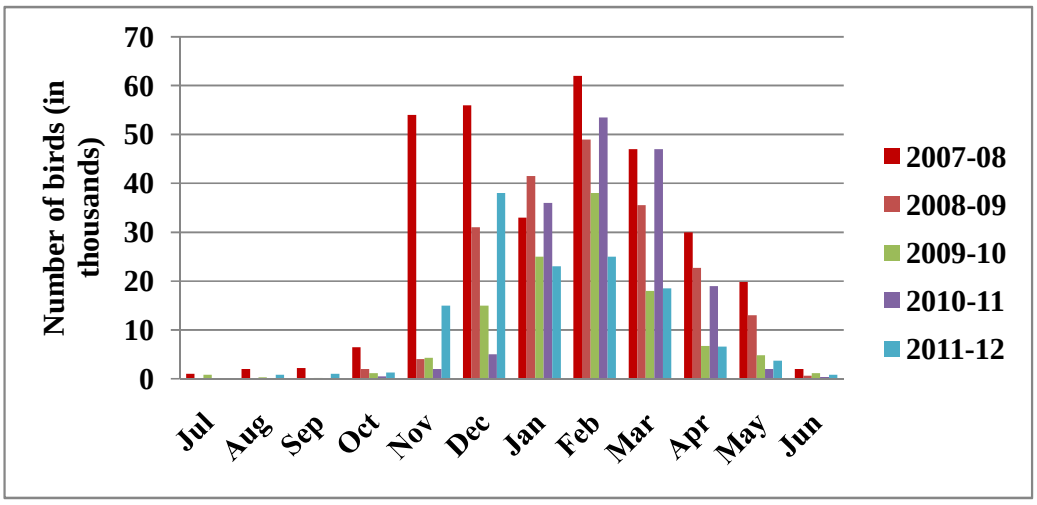

Fig. 5. Absolute number of waterfowl in different months during the study period.

A maximum of 64 species of waterfowl were recorded in March 2007-08 and the minimum 14 species were recorded in July and August 2011-12. Whereas, the individual number varies from 62,028 in February 2007-08 individuals in August 2009-10. In the five years of monthly counts significant variations of bird populations were observed during the winter season when the migratory birds arrive at this wetland. The terrestrial birds do not have any correlation with waterfowl populations as their numbers were significantly low and the populations were almost constant throughout the year. This attributes to lack of proper tree cover in the vicinity of Kolleru wetland and other suitable habitat features not congenial to terrestrial bird life.

Species Diversity and Evenness

Diversity indicates the richness of species both in quality and quantity. The total number of birds did not employ the concept of the diversity. Several factors such as area, water depth and habitat diversity might influence the diversity of species (Krebs, 1982). The diversity also influenced by species heterogeneity (Simpson 1969; Mac Arthur 1965) or climatic irregularity (Klopfer 1959, Mac Arthur 1965 and Rotenbern 1978). The present study of diversity is not correlated with the climatic and habitat variation parameters, but the diversity index formulates with the richness and evenness of the species. This has been illustrated in the (Table. 4, 5).

Table 4. Relationship between total bird population, species diversity and equally common species at Kolleru lake during the study period.

S. no.	Item	2007-08	2008-09	2009-10	2010-11	2011-12
1.	Number of species	123	112	109	118	101
2.	Number of Birds	26,078	16,694	9,592	14,140	11,222
3.	Species Diversity	1.20	1.74	1.82	1.84	1.88·
4	Equaly Common Sps.	0.36	0.54	0.54	0.57	0.55

Table 5. Relationship between the waterbird population, species diversity and equally common species at Kolleru lake during the study period.

S. no.	Item	2007-08	2008-09	2009-10	2010-11	2011-12
1.	Number of species	64	54	58	58	56
2.	Number of Birds	26,302	16,847	9,768	14,340	11,388
3.	Species Diversity	1.47	2.00	2.18	2.24	2.18
4.	Equaly Common Sps.	0.35	0.52	0.53	0.61	0.53

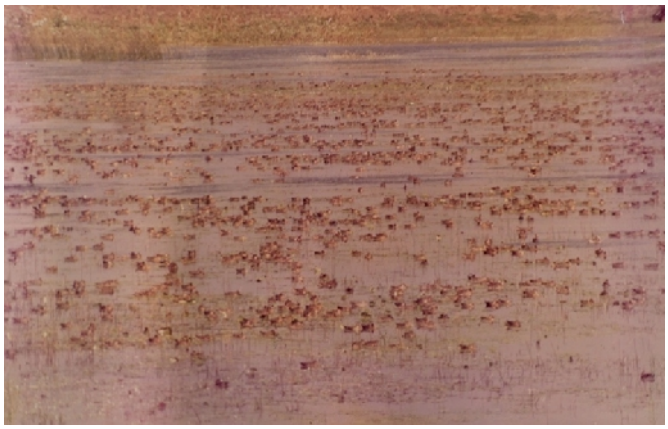

Plate 1: A profusion of migrant species a variety of ducks seen from Oct- March.

Plate 2: The painted storks are the dominant species amongst local migrant**.**

The maximum number of 123 species having an average bird number 26,078 having 1.20 diversity and 0.36 evenness in 2007-08. The maximum representation of 101 species having 11,222 birds has shown 1.88 diversity and 0.55 evenness in 2011-12. In waterfowl populations maximum 64 species having 26,303 birds recorded in 2007-08 has 1.47 species diversity and 0.35evenness. The minimum representation of 54 species having 16,844 exhibits the species diversity 2.00 and the evenness 0.52 in the year 2009-10. The diversity index is fluctuating with an increasing and decreasing sequence ranging from 1 to 5.3 in overall bird populations and 0.5 to 2.3 in waterfowl populations. Likewise the diversity the evenness is also fluctuating, the evenness varies between 0.20-0.80 in all the bird populations including water birds. Thus no empirical relationship is exiting between the bird diversity and evenness.

The implications of the results are set in the tables and figures clearly which indicates that the number of species and the number of individuals have significantly decreased in the recent years. This is due to the expansion of aquaculture and agriculture in waterfowl areas in recent years. The other indirect factors include deterioration of water quality, vegetational changes, and disturbance – through boat movements, cattle grazing, constriction of road bridges and poaching. Similar observations were recorded elsewhere in India (Anjaneyulu 1984, Vijayan 1987). Taher and Taher (1996) Vijay Kumar and Choudary (1994) and Sabesh, (2010). Many workers (Bolen 1982, Fredrickson, 1986) studied the causative factors affecting on bird populations in the wetlands of United States and in Canada. The numbers of many common waterfowl have decreased dramatically and many species have become extinct or extrapolated due to the destruction of wetland habitat (Fedrickson 1982). The same holds true to a great extent for Kolleru Wetland also.

The current use of land for human habitations and for road & bridge construction should be stopped otherwise it resulted in to breaking up organic continuity of the lake. Efficient treatment of human refuse and garbage will minimize organic pollution. The practice of using exposed lakebed for agriculture is to be discouraged. The shift to extensive fish culturing in a large number of fishponds has to be carefully planned. To mitigate the effect on the wetland more effective steps for control of poaching should be mounted for habitat preservation.

ACKNOWLEDGEMENT

The authors are sincerely extend their thanks to ICAR for providing financial support. Our thanks are also to Acharya N.G. Ranga Agricultural University, Hyderabad for providing necessary facilities during the field work. Finally we extend our thanks to AP forest Department for granting permission to collect data and their support during the field work.

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