IARJSET

ISSN (Online) 2393-8021
ISSN (Print) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Vol. 7, Issue 6, June 2020

Status Assessment and Mitigation Measures to Preserve Water Birds and their Habitats Amidst Urban Ecosystem, Mysore, India

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Abstract: Systematic field investigations were conducted at few Lakes amidst Mysore during September, 2019 to March, 2020 to record the water birds status by following standard methods. Total 33 water bird species were recorded, which belong to 10 orders and 15 families at five Lakes and their relative abundance varied considerably. Painted stork (*Mycteria leucocephala*), northern Shoveler (*Spaula clypeata*) and little Grebe (*Tachybaptus ruficollis*) population were high compared to other species. Among water birds, 23 amphibious and 10 aquatic species were recorded. Of all, 17 species were resident birds, nine species were migratory species and seven species were local migrants. Further, feeding habits of these birds varied considerably. There were 24 species carnivorous and nine species omnivorous in their feeding habits. Furthermore, nesting activities of these water birds occurred during different seasons. Surprisingly, most of the Lakes were facing threats due to various man-made activities and 13 threats were common at different Lakes, required mitigation. Total, 20 mitigation measures are suggested, which are very much required to maintain and manage the normal conditions of these lakes amidst urban area.

Keywords: Urban Area, Water Birds, Status, Mitigation Measures.

I. INTRODUCTION

Water birds live at diversified wetland ecosystems with elite strategic power of flight to access aquatic, arboreal and terrestrial ecosystems. They represent diverse group of vertebrates (Jordan and Verma, 2000), becomes part of various aquatic ecosystems. Water birds support different food chains and food webs found amidst diversified aquatic ecosystems to lead normal survival (Grimmett and Inskipp, 2011). Hence, water birds become inseparable elements of water habitats. Several authors have recorded the importance of water birds amidst diversified water habitats around the world. Yang *et al.* (2005), Boldreghini and Dall'alpi (2008), Inac *et al.* (2008), Rajpar and Zakaria (2010), Lameed (2011), Balkhande (2012), Donatelli *et al.* (2013), Klemetsen and Knudsen (2013), Shao *et al.* (2014), Henkanththgedara and Amarasinghe (2015), Odewumi *et al.* (2017), Dauda *et al.* (2017), Wijesundara *et al.* (2017) have published the reports on various aspects of water birds at Turkey, Italy, Malaysia, Nigeria, Brazil, Tanzania, Norway, China, Sri Lanka and Pakistan.

Similarly, in India, several authors (Kumar et al., 2005; Basavarajappa, 2006; Mohan and Gaur, 2008; Bhatnagar et al., 2008; Bhat *et al.*, 2009; Kumar and Gupta, 2009; Birasal, 2010; Ravikumar, 2011; Rajashekara and Venkatesha, 2011; Hussain *et al.*, 2012; Bhadja and Vaghela, 2013; Kanaujia *et al.*, 2013; Bhadouria *et al.*, 2014; Dayand, 2014; Manjunath and Joshi, 2014; Konkal and Ganesh, 2014; Patil and Ganesh, 2014; Teneson and Ravichandran, 2015; Cross *et al.*, 2015; Harisha, 2016; Puri and Virani, 2016; Rubina *et al.*, 2016; Shruthi and Basavarajappa, 2016; Wanjari and Washim, 2016; Baraker and Kadadevaru, 2017; Bora *et al.*, 2017; Satisha *et al*., 2020; Sujosha *et al.*, 2020) have recorded water birds at various water habitats. Since, Mysore is the second most populous city in Karnataka after Bangalore. It is considered as one of the fast growing cities in Karnataka, densely populated with more than one million populations (Anonymous, 2011). The city experiences tropical monsoon climate which is a product of the interplay of two opposing air masses of the south-west and the north-east monsoons and created agreeable, cool with equable temperature and exhibit salubrious climate around the year (Kamath, 2001). All these conditions have created congenial habitat for many bird species at different Lakes located in and around Mysore. Moreover, many birds are coming from different parts of India and the world, visiting these Lakes during different seasons. Reports on water birds, habitat conditions are meager. Few published reports are available on bird's population and the physico-chemical composition of few lakes in Mysore. Guruprasad (1997), Ravikumar *et al.* (1999), Mahesha and Balasubramanian (2010), Sapthagirish *et al.* (2015), Hanieh

and Mokshapathy (2016), Upadhyaya and Chandrakala (2016), (Adarsh and Manasa, 2019), Shivaprakash *et al.* (2019) have recorded the birds population along with few physico-chemical parameters in few Lakes. However, published reports on status and threats faced by the Lakes in and around Mysore are sparse. Hence, the present investigation was carried out.

II. METHODS AND MATERIALS

Study area: Mysore is one of the heritage cities in India, located between 11°45' to 12°40' N. latitude and 75°57' to77°15' E. longitude with an elevation 770 meters above msl. It is situated in the southern area of the Deccan Plateau in Karnataka (Kamath, 2001). The city has undulating topography with typical slope from north to south. The general ground elevation of the city ranges from equally north-west to the north-east and north-south parts respectively with 40 and 25 meters differences. Five Lakes are located in and around Mysore city. Few details of these Lakes are shown in Table I.

Methodology: Systematic field investigations were conducted in five lakes namely: Bogadi, Dalavai, Karanji, Kukkarahalli and Lingambudi amidst Mysore during September, 2019 to March, 2020. Water birds were observed by following random sampling method as per Basavarajappa (2006). Five study sites were selected at these five Lakes and variable width line transact (VWLT) was used during birds observation as described by Burnham *et al.* (1980) and Jayson and Mathew (2002). Each Lake was visited every week and spent three to four hours during morning and evening hours. Total 150 line transects with 100 meters length was earmarked and birds were observed using a Nikon action 16x50CF binocular and photographed with the help of Canon EOS 70D (W/Ef-S18-135mm) camera. Birds were critically observed and collected data was used to classify them into amphibious and aquatic birds based on their time spent in water and on land and also with the help of field guides published by Ali (1996), Ali and Ripley (1983 & 1987), Sonobe and Usui (1993), Woodcock (1980) and Manakkadan and Pittie (2001). Moreover, feeding, nesting, migrating birds and threats prevailed at different Lakes were collected by using pre-tested questionnaire as per Gill (2007).

Statistical analysis: The relative abundance, percent occurrence of water bird species was calculated as per Basavarajappa (2006). Relative Dominance = ni X 100/N, where ni = number of individuals of the species; N= the total number of individuals of all the species seen during the study period. Moreover, percent occurrence = number of individuals of the species /number of individuals of all species x 100 by following standard methods (Saha, 2009).

III. RESULTS

Water birds: Total 33 water birds species were recorded at five lakes in and around Mysore (Table II). The common name, scientific name, order, families and their relative abundance is given in Table II. Among water birds, painted stork (*Mycteria leucocephala*), northern shoveler (*Spaula clypeata*) and little grebe (*Tachybaptus ruficollis*) relative abundance were high compared to other bird species and it was respectively 17.6, 15.2 and 11.1% (Table II). Remaining water birds relative abundance was below 10%. However, the lesser whistling duck (*Dendrocygna javanica*), wood sandpiper (*Tringa glareola*), common kingfisher (*Alcedo atthis*), white-throated kingfisher (*Halcyon smyrnensis*), common moorhen (*Gallinula chloropus*), white breasted water hen (*Amaurornis phoenicurus*), white browed wagtail (*Motacilla maderaspatensis*), black crowned night heron (*Nycticorax nycticorax*), great egret (*Ardea alba*), little egret (*Egretta garzetta*), purple heron (*Ardea purpurea*), black headed ibis (*Threskiornis melanocephalus*), little cormorant (*Microcarbo niger*) and oriental darter (*Anhinga melanogaster*) relative abundance was >1% at these Lakes (Table II). Table III shows order and family of water birds. Pelicaniformes represented with 11 species and it was followed by Charadriiformes, Gruiformes, which represented respectively with 6 and 4 species (Table III). Moreover, the members of Anseriformes and Suliformes were with three species each found in different Lakes in and around Mysore. However, Coraciiformes are with two species and Apodiformes, Ciconiiformes, Passeriformes and Podicipediformes were with one species each living at different Lakes (Table III). Further, these 10 orders hosted 16 families and their species composition was uneven at different Lakes in and around Mysore (Table III). In general, Ardeidae family contributed seven species and it was followed by Rallidae with four species which were living at different Lakes (Table III). Moreover, three species belong to Threskiornithidae and two species belong to Alcedinidae families were found at all the Lakes in and around Mysore (Table III). Apodidae and Podicipediae (One species each) and Charadriidae, Phalacrocoracidae and Scolopacidae (Two species each) family members found in Dalavai, Karanji, Kukkarahalli and Lingambudi Lakes (Table III). Further, Recurvirostridae and Pelicanidae (One species each) found in Kukkarahalli and Lingambudi Lakes. However, Anatidae (Three species each) and Ciconidae (one species) family members were present in Karanji, Kukkarahalli and Lingambudi Lakes (Table III). The Jacanidae (One species) family member was found in

Dalavai, Karanji and Kukkarahalli Lakes (Table III). The Motacillidae (One species) found in Bogadi, Karanji, Kukkarahalli and Lingambudi Lakes). Only Anhingidae (One species) found in Kukkarahalli Lake (Table III).

Amphibious and aquatic birds: Table IV indicates the amphibious and aquatic birds found at different Lakes in and around Mysore. Total 23 amphibious and 10 aquatic birds represented respectively 69.7 and 30.3% at different Lakes (Tables IV and V). The white throated kingfisher, cattle egret, little egret and pond heron were found at all the Lakes. The spot-billed duck and yellow-wattle lapwing are amphibious in their existence, found at Kukkarahalli and Lingambudi Lakes. The black-winged stilt and spot-billed pelican are purely aquatic, found at Kukkarahalli and Lingambudi lakes. The common moorhen, white breasted water hen and black crowned night heron are amphibious birds living in Karanji and Kukkarahalli Lakes only. Moreover, lesser whistling duck is found only in Karanji Lake, northern sholvere found only at Lingambudi Lake and oriental darter was found only in Kukkarahalli Lake during the present study. However, remaining birds were found at different Lakes in and around Mysore (Tables IV and V). Further, among the five lakes, Kukkarahalli Lake hosted 30 species (20 amphibious and 10 aquatic bird species), it was followed by Lingambudi Lake with 25 species (18 amphibious and 7 aquatic bird species), Karanji Lake was with 23 species (17 amphibious and 6 aquatic bird species) and Dalavi Lake was with 20 species (15 amphibious and 5 aquatic bird species), whereas, Bhogadi Lake had only 10 amphibious bird species and aquatic bird species were absent during most of the study period.

Status of water birds: Further, status and nesting activity of water birds are shown in Table VI. Total 17 species were resident birds residing at different Lakes. Seven bird's species were local migrants living amidst different Lakes. However, nine species were migratory birds, visiting different Lakes during different seasons (Table VI). The percent occurrence of resident, local migrant and migratory birds at different Lakes in and around Mysore was respectively 51, 27.3 and 21.2% (Tables VI and VII). Further, rare and commonly occurring birds species are presented in Table VII. The uncommonly found species were lesser whistling duck, wood sandpiper, common kingfisher, white-throated kingfisher, common moorhen, purple more hen, white-breasted water hen, black crowned night-heron, cattle egret, great egret, grey heron, little egret, pond heron and little cormorant. Around 13 bird's species were commonly found at different Lakes (Table VII). Moreover, percent occurrence of water birds is given in Table VII.

Nesting: Nesting is one of the vital activities; help for good progeny production. This in turn helps support the continuance of species from one generation to the other. Although, nesting is species specific and is a seasonal activity for many water bird's species (Table VIII). The pond heron, little grebe and great cormorant species are conducting nesting activities throughout the year. However, 11 species preferred late summer and early rainy seasons and 8 species preferred late winter and early summer seasons for nesting at different Lakes in and around Mysore (Table VIII). Total five species (e.g. bronze winged jacana, common coot, common moorhen, purple moorhen and spot-billed duck) are conducting nesting activities during rainy season. Four species depended during late rainy and early winter seasons for nesting in different lakes. Moreover, around eight species have preferred late winter and early summer for their nesting activities at different lakes of Mysore (Table VI). Moreover, 11 species have opted late summer and early rainy seasons for their nesting activities in different Lakes of Mysore. However, pond heron and red-napped ibis conducted their nesting activities during winter season at different Lakes. Further, percent occurrence of nesting activities occurred during different seasons by different water bird species and the duration required to complete nesting activities is given in Tables VI and VIII.

Food habits: Feeding behavior of water birds at different Lakes in and around Mysore is depicted in Table IX. Total nine water bird species were omnivores, which feed on vegetables, seeds, wild grass shoots, roots and their rootlets along with fishes, insects, mollusks and worms. Total 24 water bird species were carnivores feed on fishes, frog tadpoles, reptiles, mollusks, insects and worms (Table IX). Further, percent preference of different type of food by the water birds is given in Table X. Total 14 species were fishivores, feeding on fishes. Around 27 species feed on aquatic insect's larva, pupa and adults. 14 species feed on mollusks, 6 bird species feed on worms and larva, and five bird species feed on reptiles. Five bird species feed on wild grass roots and rootlets, tender shoot, five species feed on wild grass and seeds and two species feed on vegetables (Table X). Spot-billed pelican, great cormorant, little cormorant and darter were exclusively depended on fishes for their feeding. Furthermore, percent preference of different food by water birds is depicted in Table X.

Threats recorded at different Lakes: The major threats experiencing at different Lakes in and around Mysore is depicted in Table XI. Total 13 threats were commonly recorded during the present investigation, which were almost similar at most of the Lakes. The Dalavai Lake is experiencing encroachment problem along with denudation of trees,

shrubby vegetation and human interference at its premises. Moreover, eutrophication is another major problem at Dalavai Lake (Table XI). Similarly, Kukkarahalli Lake, Karanji Lake, Bhogadi Lake and Lingambudi Lakes are facing different types of threats. The type of threat encountered during the present study and their percent occurrence is given in Table XII. Furthermore, major threats recorded at different lakes during the present study are given in Table XIII. Bogadi and Dalavai Lakes are facing major threats (25%) and it was followed by Kukkarahalli Lake (22.7%) compared to other Lakes, where it was 13.7% each at Karanji and Lingambudi Lakes (Table XIII). Thus, all the five Lakes located in and around Mysore are facing different types of threats and need mitigation measures.

Mitigations to conserve water birds and their habitat: Various mitigation measures are suggested to different Lakes located in and around Mysore (Table XIV). Altogether, 20 mitigation measures are suggested, which are very much required to maintain and manage the normal conditions in these Lakes. Among the suggested mitigations, prohibition of wild grass and shrubby vegetation removal and clearance of weeds and toxic algae in the Lake water requires immediate attention at most of the Lakes. Moreover, establishing inlets for proper rainwater harvesting is essential to maintain quantity and quality of water in the Lakes. Further, periodic analysis of physcio-chemical and biological parameters of water of all the Lakes should be carried out to manage the water quality during different seasons. Furthermore, planting fruit yielding species and location specific silting are important to upkeep these Lakes ecosystem alive throughout the year. Besides, creating awareness on water bird species, installing displaying boards with important features of water birds on either sides of walking path in the Lake premises, encouraging Lake management board by including the interested citizens, biologists, wildlife experts help solve burning issues of Lakes amidst urban area.

VI. DISCUSSION

Water habitats with diversified vegetation influence the diversity of bird species (Jayson and Mathew, 2002; Basavarajappa, 2006). During the present investigation, 33 water birds species which belong to 10 orders and 16 families were living at different Lakes in and around Mysore. These water birds species were not uniformly distributed among different Lakes. In general, Ardeidae, Rallidae Threskiornithidae and Alcedinidae family members were commonly found at all the Lakes. However, Apodidae, Podicipediae, Charadriidae, Phalacrocoracidae, Scolopacidae, Recurvirostridae, Pelicanidae, Anatidae, Anhingidae, Jacanidae and Motacillidae family members with different species composition found at few Lakes in and around Mysore. This shows their heterogeneous habit and habitats (Ali and Ripley, 1987). Further, grouping of water birds into amphibious and aquatic species based on the habit, habitat, and time spent in water and on land, feeding in water or on the bank of Lake/Pond or nearby water body during different hours of the day would help understand the status and specific living conditions prevailed at various water habitats. Bird species which depend exclusively on water prefer open water surface which is devoid of submerged or rooted vegetation for easy feeding of fishes and aquatic insects (Basavarajappa, 2006). The water habitats free from such vegetation harbor common coot, spot-billed pelican, little grebe, cormorants, darter, painted stork, stilts and sandpipers. As these species feed on fishes and other aquatic organisms, prefer open water conditions. While, amphibious birds depend both on land and water for their living conditions (Ali, 1996). They are more common at partial or completely eutrophicated Lakes, where open water is very less and the whole water body is covered with rooted, submerged and floating vegetation. Further, amphibious birds feeding habits are highly diversified compared to aquatic birds. They feed on mollusks, worms, aquatic adult and juvenile insect forms (e.g. larva, pupa, nymph, naiad and grub), fishes, tadpoles along with wild grass seeds, hydrophytes shoots, rootlets etc (Basavarajappa, 2006). During the present study, 24 amphibious bird species such as ducks (e.g. lesser whistling duck, northern shoveler and spot-billed duck), lapwings (e.g. red-wattle lapwing and yellow-wattle lapwing), kingfishers (e.g. white-throated kingfisher and common kingfisher), water hens (e.g. common moorhen, purple moorhen, white breasted water hen), herons (e.g. black-crowned night heron, grey heron, pond heron, purple heron) egrets (e.g. cattle egret, great egret, little egret), ibises (e.g. black-headed ibis, glossy ibis, red-napped ibis), swift, jacana, wood sandpiper and wagtail were found amidst partially eutrophicated Lakes.

Kukkarahalli Lake has hosted 30 species, of which 20 were amphibious and 10 aquatic species. The Kukkarahalli Lake is overgrown with water hyacinth *Eichornia crassipes* and grass species, large plantations include *Tectona grandis*, *Eucalyptus* and *Acacia* species are interspersed with *Bambusa arundinaria*, *Lantana camara* and several weed species e.g. *Parthenium hysterophorus* and *Euphorbia* species which have provided roosting, resting and nesting sites for many amphibious and few aquatic birds. While, Lingambudi Lake has hosted 25 species, of which 18 were amphibious and 7 aquatic species. It is a perennial Lake with different tree species (e.g. *Pongamia pinnata*, *Acacia* sps, *Mangifera indica*, *Syzygium cumini*, *Ziziphus* sp.) have provided good habitat for domestic as well as migratory birds. Moreover, shoreline is covered by *Typha*, *Scripus*, *Pandanus* and *Phoenix* species. All these vegetation might have provided amphibious habitat for many water birds. Karanji Lake has hosted 23 species, of which 17 were amphibious and six were aquatic species. It is one of the biggest Lakes in Mysore District provided suitable site for many resident and migratory birds. Dalavi Lake has hosted 20 species, of which 15 were amphibious and five were aquatic species. The main source of

water to Dalavai Lake is rainfall, urban runoff from the elevated areas through storm water drains and sewage water from Mysore city. Sometimes, water also comes from the irrigation return flow from Varuna canal distributaries. However, Bhogadi Lake has hosted only 10 amphibious bird species. There were no aquatic bird species due to lack of water during most of the study period. Perhaps, prevailed specific conditions at these Lakes might have attracted different water birds species in this area. This shows the water birds specificity and their ability to access different water habitats without any competition between the species to lead normal survival. Thus, water birds have diversified habits and habitats, prefer safe and congenial water habitats and it is witnessed at different Lakes in and around Mysore during the present study. Similar types of observations were reported by Rajashekara and Venkatesha (2011), Harisha (2016), Rubina *et al.* (2016) and Shruthi and Basavarajappa (2016) at different lakes located at Bangalore, Davangere, Dharwad and K.R. Nagar. Further, during the present study, 18% bird's species were found psicivorous, which feed on fingerlings and adult fishes, 34% bird's species were insectivorous; feed on larva, nymph and adult insects amidst water habitat. Remaining 18% birds were feeding on mollusks, 7.7% water birds feeding on worms and tadpoles and 6.4% water birds preferred to feed on reptiles.

Water habitats are potential sources for diversified flora and fauna. The bushy scrub and stray trees on the bank of water habitats may provide good conditions for various water birds species for roosting, resting and nesting activities. Moreover, floating and submerged vegetation may harbor crabs, snails, calms, worms, insect larvae and pupae which constitute the food of many water birds (Basavarajappa, 2006). Water birds species belong to different groups are very specific in their roosting, resting, nesting, feeding behavior and never compete for similar living conditions. However, they live together and become part of different food chains and food web amidst inland water habitats (Rubina *et al.*, 2016; Shruthi and Basavarajappa, 2016). Similar type of observation was made by Uttangi (2001). Lakes in and around Mysore have hosted few migratory birds species besides residents and local migrant species. The northern shoveler, common sandpiper, painted stork, common coot, white browed wagtail, spot-billed pelican, glossy ibis, black-headed ibis and red-napped ibis are migratory birds, visiting regularly to different lakes to access and avail prevailed congenial climate, locally available abundant food to have safe survival during their visit. Similar type of observations were made by Wanjari and Wasim (2016), Bhat *et al.* (2009), Birasal (2010), Ravikumar (2011), Rubina *et al.* (2016), Shruthi and Basavarajappa (2016), Puri and Virani (2016) at Maharashtra, Udapi, Haveri, Hassan, Dharwad and Mysore Districts.

However, in the recent years, the different Lakes in and around metropolitan cities/towns are facing more anthropogenic interferences due to various reasons. Presently, Mysore is one of the fast growing cities in India and second most populous city in Karnataka after Bangalore (Kamath, 2011). It is densely populated with more than one million populations (Anonymous, 2011) and accordingly more pressure is created on the land to establish residential areas. It led to encroachment and production of enormous quantity of waste. Lakes are experiencing threats, which were almost similar between them. The encroachment problem along with denudation of trees, shrubby vegetation and human interference at or nearby water habitats are major ones and eutrophication is another big problem to few Lakes (e.g. Dalavai Lake and Kukkarahalli Lake). Similarly, Karanji Lake, Bhogadi Lake and Lingambudi Lakes are facing different types of threats and need monitoring. To overcome such threats, 20 mitigation measures are suggested. Prohibition of wild grass and shrubby vegetation removal and clearance of weeds and toxic algae in the Lake water, proper rainwater harvesting, periodic analysis of physcio-chemical and biological parameters of water of all the Lakes, planting fruit yielding species and location specific silting requires immediate attention at most of the Lakes. This requires scientific monitoring and documentation to upkeep these Lakes ecosystem alive throughout the year. Our observations are on par with the observations of Uttangi (2001), Gill (2007) and Chace and Walsh (2006). Thus, water bird's species habit and habitats are more diversified and requires suitable forage, roosting, resting, nesting and breeding sites to have safe survival. Further, few birds species are seasonal migrants, visiting a particular lake that could help reveal their unique life supporting requirements available at such Lakes to lead better life during their visit. To understand all these behavior at every Lake requires in-depth investigations. Such types of studies are very essential in the present context to develop scientific conservation measures to protect water birds amidst different water habitats at urban area. Hence, present study provided an insight about the status, commonly occurring threats and few mitigation measures to restore few water birds' species along with their habitats at urban area.

V. CONCLUSION

Different Lakes located in and around Mysore have hosted 33 water birds species, of which 24 species were amphibious and nine species were aquatic. Moreover, 17, 9 and 7 species were respectively resident birds, migratory birds and local migrants. Further, 13 bird's species were commonly found at different Lakes. Similarly, 13 bird's species were rare in their appearance at different Lakes. And, seven species were more abundant at different Lakes. Total nine water bird species were omnivores and 24 water bird species were carnivores. Further, nesting activity of water birds varied considerably and few birds were more specific. Since, aquatic birds are very essential, playing pivotal role in different

food chains and food web at different trophic levels. Furthermore, migratory birds visit Lakes during different seasons that indicate quality and presence of good life supporting conditions for their safe survival during specific season. Water birds offer undisturbed, pollution free environment with zero human interference at their preferred habitats. All these activities have direct influence on the survival of water bird's population. Therefore, to restore locally existing water birds amidst different lakes, precautions should be undertaken to conserve and create awareness about water habitats. As Lakes acts like lungs of urban area, preserving such water habitats by establishing abundant forage, congenial conditions with minimum human interference for nesting and breeding activities could help produce good progeny for future generation. Therefore, simple investigations of this kind could collect lot of scientific information that should be used to frame proper conservation measures to restore local water habitats amidst urban area.

ACKNOWLEDGEMENT

Authors are thankful to the Executive Director, Sri Chamarajendra Zoological Gardens, Mysore for the permission to visit Karanji Lake. We are thankful to the Forest Officers, Karnataka State Forest Department, Mysore for providing permission to visit Lingambudi Lake. Thanks are also due to the Chairperson, DOS in Zoology, University of Mysore, Manasagangotri, Mysore for providing necessary facilities. Some Part of the work is benefited from the PSFS/Laboratory Grants, DOS in Zoology, University of Mysore, Mysore.

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Table I: Lakes in and around Mysore

Sl. No.	Lake Name	Geographical Location	Water Catchment Area	Major Threats Recorded*
1.	Bogadhi	12^0 31'69" N. latitude, $76^0$59'83'' E. longitude	NA	1, 2, 3, 4, 5, 6, 8, 10, 11 & 12
2.	Dalvai	12^0 15' N. latitude, 76^0 39' E. longitude	NA	1, 2, 3, 4, 5, 6, 7, 10, 11, 12 & 13
3.	Karanji	12°18′10″N. latitude 76°40′25″E. longitude	55 hectares	1,5,7,8,9 & 13
4.	Kukkarahalli	12.30°N. latitude, 78.63°E. longitude	4.5 sq. km	1, 3, 5, 6, 9,12 & 13
5.	Lingambudi	12° 16′ 9.74″ N. latitude, 76° 36′ 43.12″ E. longitude, 730 m above the sea level	45 sq. km	2,5,10,11,12 &13

(Source: Kamath, 2001 and Google earth.com) Note: NA: Data not available.

* Details given in Table XI.

Table II: Water birds at different Lakes of Mysore, Karnataka, India (N=56)

Sl. No.	Common Name - Scientific Name	RA (%)	Order/Family
1.	Lesser Whistling Duck - *Dendrocygna javanica*	0.3	Anseriformes : Anatidae
2.	Northern Shoveler - *Spatula clypeata*	15.2	
3.	Spot - billed Duck - *Anas poecilorhyncta*	6.9	
4.	Asian-Palm Swift - *Apus apus*	1.6	Apodiformes: Apodidae
5.	Red - wattle Lapwing - *Vanellus indicus*	5.7	Charadriiformes: Charadriidae
6.	Yellow - wattle Lapwing - *Vanellus malabaricus*	1.4	
7.	Bronze - winged Jacana - *Metopidius indicus*	1.3	Charadriiformes: Jacanidae
8.	Black-winged Stilt - *Himantopus himantopus*	1.9	Charadriiformes: Recurvirostridae

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9.	Common Sandpiper - *Actitis hypoleucos*	1.1	Charadriiformes: Scolopacidae
10.	Wood Sandpiper - *Tringa glareola*	0.6	
11.	Painted Stork - *Mycteria leucocephala*	17.6	Ciconiiformes : Ciconiidae
12.	Common Kingfisher - *Alcedo atthis*	0.4	Coraciiformes : Alcedinidae
13.	White-throated Kingfisher - *Halcyon smyrnensis*	0.7	
14.	Eurasian Coot - *Fulica atra*	2.8	Gruiformes: Rallidae
15.	Common Moorhen- *Gallinula chloropus*	0.3	
16.	Purple Moorhen - *Porphyrio porphyrio*	7.5	
17.	White Breasted Water Hen - *Amaurornis phoenicurus*	0.1	
18.	White browed Wagtail - *Motacilla maderaspatensis*	0.3	Passeriformes: Motacillidae
19.	Black Crowned Night-heron - *Nycticorax nycticorax*	0.4	Pelicaniformes: Ardeidae
20.	Cattle Egret - *Bubulcus ibis*	6.0	
21.	Great Egret - *Ardea alba*	0.7	
22.	Grey Heron - *Ardea cinerea*	1.5	
23.	Little Egret - *Egretta garzetta*	0.7	
24.	Pond Heron - *Ardeola grayii*	4.1	
25.	Purple Heron - *Ardea purpurea*	0.9	
26.	Spot - billed Pelican - *Pelecanus philippensis*	2.0	Pelicaniformes: Pelicanidae
27.	Black - headed Ibis - *Threskiornis melanocephalus*	0.8	Pelicaniformes: Threskiornithidae
28.	Glossy Ibis - *Plegadis falcinellus*	1.6	
29.	Red- napped Ibis - *Pseudibis papillosa*	2.1	
30.	Little Grebe - *Tachybaptus ruficollis*	11.1	Podicipediformes: Podicipedidae
31.	Great Cormorant - *Phalacrocorax carbo*	1.5	Suliformes: Phalacrocoracidae
32.	Little Cormorant - *Microcarbo niger*	0.7	
33.	Oriental Darter - *Anhinga melanogaster*	0.2	Suliformes: Anhingidae
Total		100.0	-

Note: RA: Relative Abundance.

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Table III: Order and family of water birds (N= 56)

Sl. No.	Order		Family		Lakes name
	Name	No. of species	Name	No. of species	
1.	Anseriformes	03	Anatidae	03	KL, KKL, LL
2	Apodiformes	01	Apodidae	01	DL, KL, KKL & LL
3.	Charadriiformes	06	Charadriidae	02	DL, KL, KKL & LL
			Jacanidae	01	Dl, KL & KKL
			Recurvirostridae	01	KKL & LL
			Scolopacidae	02	DL, KL, KKL & LL
4.	Ciconiiformes	01	Ciconiidae	01	KL, KKL & LL
5.	Coraciiformes	02	Alcedinidae	02	All
6.	Gruiformes	04	Rallidae	04	All
7.	Passeriformes	01	Motacillidae	01	BL, KL, KKL & LL
8.	Pelicaniformes	11	Ardeidae	07	All
			Pelicanidae	01	KKL & LL
			Threskiornithidae	03	All
9.	Podicipediformes	01	Podicipedidae	01	DL, KL, KKL & LL
10.	Suliformes	03	Phalacrocoracidae	02	DL, KL, KKL & LL
			Anhingidae	01	KKL
Total		33	Total	33	-

Note: Data is based on Table II.

BL: Bogadi Lake; DL: Dalavi Lake; KL: Karanji Lake; KKL: Kukkarahalli Lake and LL: Lingambudi Lake.

DOI 10.17148/IARJSET.2020.7623

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Table IV: Type and status of water birds found at different Lakes in and around Mysore (N=56)

Sl. No.	Bird Name	Type	Found at
1.	Lesser Whistling Duck	Amphibious	KL
2.	Northern Shoveler	-do-	LL
3.	Spot - billed Duck	-do-	KKL & LL
4.	Asian Palm Swift	-do-	DL, KL, KKL & LL
5.	Red - wattle Lapwing	-do-	DL, KL, KKL & LL
6.	Yellow - wattle Lapwing	-do-	KKL & LL
7.	Bronze - winged Jacana	-do-	DL, KL & KKL
8.	Black - winged Stilt	-do-	KKL & LL
9.	Common Sandpiper	-do-	DL, KKL & LL
10.	Wood Sandpiper	Amphibious	DL, KKL & LL
11.	Painted Stork	Aquatic	KL, KKL & LL
12.	Common Kingfisher	Amphibious	BL, DL & KKL
13.	White - throated Kingfisher	-do-	All
14.	Common Coot	Aquatic	DL, KL & LL
15.	Common Moorhen	Amphibious	KL & KKL
16.	Purple Moorhen	-do-	DL, KL, KKL & LL
17.	White Breasted Water Hen	-do-	KL & KKL
18.	White Browed Wagtail	-do-	BL, KL, KKL & LL
19	Black Crowned Night - heron	-do-	KL & KKL
20.	Cattle Egret	-do-	All
21.	Great Egret	-do-	BL, DL, KKL & LL
22.	Grey Heron	-do-	BL, KL & KKL
23.	Little Egret	-do-	All
24.	Pond Heron	-do-	All
25.	Purple Heron	-do-	BL, KL, KKL & LL
26.	Spot - billed Pelican	Aquatic	KKL & LL
27.	Black - headed Ibis	Amphibious	BL, DL, KKL & LL
28.	Glossy Ibis	-do-	DL, KL, KKL & LL
29.	Red- napped Ibis	-do-	DL, KL, KKL & LL

DOI 10.17148/IARJSET.2020.7623

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30.	Little Grebe	Aquatic	DL, KL, KKL & LL
31.	Great Cormorant	-do-	DL, KL, KKL & LL
32.	Little Cormorant	-do-	DL, KL, KKL & LL
33.	Oriental Darter	-do-	KKL

Note: BL: Bhogadi Lake; DL: Dalavai Lake; KL: Karanji Lake; KKL: Kukkarahalli Lake and LL: Lingambudi Lake.

Table V: Water bird types recorded at different Lakes in and around Mysore

Sl. No.	Bird Type	No. of species	% Occurrence
1.	Amphibious	23	69.7
2.	Aquatic	10	30.3
Total		33	100.0

Note: Data is based on Table IV.

Table VI: Type and status of water birds found at different Lakes in Mysore (N=56)

Sl. No.	Water Bird	Status		Nesting		
				Period	Season	Duration (In Months)
1.	Lesser Whistling Duck	LM	Rare	Jun. to Oct.	R & W	5
2.	Northern Shoveler	M	Abundant	Apr. to Jun.	S & R	3
3.	Spot - billed Duck	LM	Abundant	Jul. to Sep.	R	3
4.	Asian Palm Swift	LM	Common	May to Aug.	S & R	4
5.	Red - wattle Lapwing	R	Abundant	Mar. to Aug.	S & R	6
6.	Yellow - wattle Lapwing	LM	Common	Apr. to Jul.	S & R	4
7.	Bronze - winged Jacana	R	Common	Jun to Sep.	R	4
8.	Black - winged Stilt	R	Common	Apr. to Aug.	S & R	5
9.	Common Sandpiper	M	Common	May to Jun.	S & R	2
10.	Wood Sandpiper	R	Rare	May to Jun.	S & R	2
11.	Painted Stork	M	Abundant	Aug. to Jan.	R & W	6
12.	Common Kingfisher	R	Rare	Mar. to Jun.	S & R	4
13.	White - throated Kingfisher	R	Rare	Mar. to Jul.	S & R	5
14.	Common Coot	M	Common	Jul. to Aug.	R	2

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15.	Common Moorhen	R	Rare	Jun to Sept.	R	4
16.	Purple Moorhen	R	Abundant	Jun to Sept.	R	4
17.	White Breasted Water Hen	R	Rare	Jun. to Oct.	R & W	5
18.	White Browed Wagtail	M	Rare	Mar. to Sep.	S & R	7
19	Black Crowned Night - heron	R	Rare	Dec. to Feb.	W & S	3
20.	Cattle Egret	R	Abundant	Nov. to Mar.	W & S	5
21.	Great Egret	R	Rare	Jul. to Sep.	R & W	3
22.	Grey Heron	R	Common	Nov. to Mar.	W & S	5
23.	Little Egret	R	Common	Nov. to Feb.	W & S	4
24.	Pond Heron	R	Common	Nov. to Jan.	W	3
25.	Purple Heron	R	Rare	Jun. to Mar.	All	10
26.	Spot - billed Pelican	M	Common	Nov. to Apr.	W & S	5
27.	Black - headed Ibis	M	Rare	Nov. to Feb.	W & S	4
28.	Glossy Ibis	M	Common	May to Jul.	S & R	3
29.	Red- napped Ibis	M	Common	Nov. to Dec.	W	2
30.	Little Grebe	LM	Abundant	Apr. to Oct.	All	7
31.	Great Cormorant	LM	Common	Sept. to Feb.	All	6
32.	Little Cormorant	R	Rare	Nov. to Feb.	W& S	4
33.	Oriental Darter	LM	Rare	Nov. to Feb.	W & S	4

Note: R: Resident; LM: Local Migrant and M: Migratory.

Rare: Recorded < 1%; Common: Recorded < 5% and Abundant: Recorded > 5%.

S: Summer' R: Rainy; W: Winter & All: Throughout the year.

Table VII: Status of water birds at different Lakes in and around Mysore

Sl. No.	Type	No. of species	% Occurrence	Type	No. of species	% Occurrence
1.	Resident	17	51.5	Rare	13	39.4
2.	Local Migrant	7	21.2	Abundant	7	21.2
3.	Migratory	9	27.3	Common	13	39.4
Total		33	100.0	Total	33	100.0

Note: Data is based on Table VI.

Rare: Recorded < 1%; Common: Recorded < 5% and Abundant: Recorded > 5%.

DOI 10.17148/IARJSET.2020.7623

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Table VIII: Nesting activity of water birds at Lakes in and around Mysore

Sl. No.	Season	No. of species	% Occurrence
1.	Rainy & Winter	4	12.1
2.	Summer & Rainy	11	33.3
3.	Winter & Summer	8	24.2
4.	Winter	2	6.1
5.	Rainy	5	15.2
5.	All	3	9.1
Total		33	100.0

Note: Data is based on Table VI.

Table IX: Food of water birds recorded at Lakes in and around Mysore (N=56)

Sl. No.	Names	Type of food							
		F	I	M	W & T	R	G	S	V
1.	Lesser Whistling Duck	+	+	+			+		
2.	Northern Shoveler		+	+	+		+		
3.	Spot - billed Duck		+					+	+
4.	Asian-Palm Swift		+						
5.	Red - wattle Lapwing		+	+					
6.	Yellow - wattle Lapwing		+	+					
7	Bronze - winged Jacana		+	+				+	
8.	Black-winged stilt			+	+				
9.	Common Sandpiper		+	+	+				
10.	Wood Sandpiper		+	+	+				
11.	Painted Stork	+	+			+			
12.	Common Kingfisher	+	+						
13.	White - throated Kingfisher	+	+			+			
14.	Common Coot		+	+			+		
15.	Common Moorhen		+	+	+		+	+	
16.	Purple Moorhen		+	+					+
17.	White Breasted Water Hen		+	+	+		+	+	
18.	White browed wagtail		+						

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19.	Black Crowned Night - heron	+	+						
20.	Cattle Egret		+			+			
21.	Great Egret	+	+						
22.	Grey Heron								
23.	Little Egret		+			+			
24	Pond Heron	+	+						
25.	Purple Heron	+	+						
26.	Spot - billed Pelican	+							
27.	Black - headed Ibis	+	+	+					
28.	Glossy Ibis		+						
29.	Red- napped Ibis		+			+		+	
30.	Little Grebe	+	+	+					
31.	Great Cormorant	+							
32.	Little Cormorant	+							
33.	Oriental Darter	+							

Note: '+' indicates feeding.

F: Fish; I: Insect; M: Mollusks; W: Worms & Tadpoles; R: Reptiles; G: Grass; S: Seeds ad V: Vegetables.

Table X. Percent preference of different type of food by the water birds

Sl. No.	Type of Food	No. of water bird species preferred	% Preference
1.	Fish (Fingerlings & adult Fish)	14	18.0
2.	Insect (Larva, nymphs & adults)	27	34.6
3.	Mollusk	14	18.0
4.	Worms and Tadpoles	6	7.7
5.	Reptiles (Juveniles and small adults)	5	6.4
6.	Grass (Aquatic weeds)	5	6.4
7.	Seeds (Wild grass & weeds seeds)	5	6.4
8.	Vegetables (Leafy plants in the water)	2	2.5
Total		78	100.0

Note: Data is based on Table IX.

DOI 10.17148/IARJSET.2020.7623

IARJSET

ISSN (Online) 2393-8021
ISSN (Print) 2394-1588

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Table XI: Major threats recorded at different Lakes in and around Mysore

Sl. No.	Name of Threat recorded	BL	DL	KL	KHL	LL
1.	Residential sewage discharge	+	+	+	+	-
2.	Encroachment	+	+	-	-	+
3.	Fishery activity	+	+	-	+	-
4.	Birds hunting/poaching	+	+	-	-	-
5.	Human disturbance	+	+	+	+	+
6.	Livestock foraging	+	+	-	+	-
7.	Removal of wild grass	+	+	+	+	-
8.	Lack of sufficient rain water runoff	+	-	+	+	-
9.	No water outlets	-	-	+	+	-
10.	Uprooting of trees	+	+	-	+	+
11.	Clearance of shrubby vegetation	+	+	-	-	+
12.	Eutrophication	+	+	-	+	+
13.	Death due toxicity/ food poisoning	-	+	+	+	+

Note: BL: Bogadhi Lake; DL: Dalavai Lake; KL: Karanji Lake; KKL: Kukkarahalli Lake and LL: Lingambudi Lake.√ indicates required; - indicate absence.

Table XII: Major threats and their percent occurrence at Lakes in and around Mysore

Sl. No.	Threat recorded	No. of times Threat found	% Occurrence (For all the Lakes)
1.	Residential sewage discharge	4	9.1
2.	Encroachment	3	6.8
3.	Fishery activity	3	6.8
4.	Birds hunting/poaching	3	6.8
5.	Human disturbance	5	11.4
6.	Livestock foraging	3	6.8
7.	Removal of wild grass	4	9.1

IARJSET

ISSN (Online) 2393-8021
ISSN (Print) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

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8.	Lack of sufficient rain water runoff	3	6.8
9.	No water outlets	2	4.6
10.	Uprooting of trees	4	9.1
11.	Clearance of shrubby vegetation	3	6.8
12.	Eutrophication	4	9.1
13.	Death due toxicity/ food poisoning	4	9.1
Total		44	100.0

Note: Each value is a mean of 14 observations. Data is based on Table XI.

Table XIII: Major threats recorded at different Lakes in and around Mysore

Sl. No.	Lake	No. of Threat found	% Occurrence (For all the Lakes)
1.	Bogadi Lake	11	25.0
2.	Dalavai Lake	11	25.0
3.	Karanji Lake	06	13.7
4.	Kukkarahalli Lake	10	22.7
5.	Lingambudi Lake	06	13.7
Total		44	100.0

Note: Each value is a mean of 14 observations. Data is based on Table XI.

Table XIV: Mitigation measures suggested to different Lakes in and around Mysore

Sl. No.	Name of the mitigation activity suggested	BL	DL	KL	KKL	LL
1.	Diverting residential sewage discharge into the Lake	√	√	√	√	-
2.	Stopping encroachment activities	√	√	-	√	-
3.	Prohibiting Fishing	√	√	-	√	√
4.	Prohibiting Birds hunting/poaching	√	√	-	√	√
5.	Removal of walk path inside the Lake	√	-	√	√	√
6.	Avoiding the entry of livestock forage	√	√	-	√	-

DOI 10.17148/IARJSET.2020.7623

IARJSET

ISSN (Online) 2393-8021
ISSN (Print) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Vol. 7, Issue 6, June 2020

7.	Stopping wild grass cutting	√	√	√	√	√
8.	Creating path for rain water runoff into the Lake	√	√	√	√	√
9.	Establishing inlet and outlets in the Lake	√	√	√	√	√
10.	Controlling the denudation of trees	√	√	-	√	√
11.	Control of shrubby vegetation removal	√	√	√	√	√
12.	Reducing the algal bloom and removal of poisonous algae	√	√	√	√	√
13.	Creating Lake Management Board (LMB)	√	√	√	√	√
14.	Encouraging microbial enrichment in the Lake	√	√	√	√	√
15.	Taking legal measures to conserve Lakes in urban ecosystem	√	√	√	√	√
16.	Educating public and creating awareness about the importance of Lakes in Urban areas.	√	√	√	√	√
17.	Selective, location specific siltation during different seasons	√	√	√	√	√
18.	Planting fruit yielding plant species	√	√	√	√	√
19.	Displaying sign boards and birds images with their importance in Lake conservation	-	-	√	√	-
20.	Analyzing the physico-chemical and biological parameters to maintain the quality of water in Lake	√	√	√	√	√

Note: BL: Bogadhi Lake; DL: Dalavai Lake; KL: Karanji Lake; KKL: Kukkarahalli Lake and LL: Lingambudi Lake. + indicates required; - indicate absence.