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# Community composition of aquatic birds in lakes of Bangalore, India

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**Abstract**

Observations were made on the occurrence, abundance, richness, and diversity of waterbirds in 15 major lakes in Bangalore city during 2008 - 2009. During the study period 35 species of aquatic birds were recorded. The number of aquatic bird species recorded at various lakes ranged from 23 to 35. The percent abundance of waterbirds recorded in the study lakes ranged from 2.46 to 21.49 and it was significantly different ($p<0.05$). The diversity and species evenness of waterbirds in the lakes ranged from 2.07 to 3.16 and 0.32 to 0.76, respectively. There was a significant difference ($p<0.05$) in the diversity and species evenness of waterbirds among different lakes. Species richness of the bird population ranged from 2.89 to 4.01 in the different study lakes and it was not significantly different ($p>0.05$). There was a variation in number of waterbird species recorded during summer, monsoon and winter seasons. Of the 35 waterbird species, *Bubulcus ibis* showed cent percent frequency, whereas less frequently (4.44%) observed species was *Anas platyrhynchos*. Among various waterbird species, *Bubulcus ibis, Fulica atra, Tringa hypoleucos, Motacilla maderaspatensis, Phalacrocorax niger, Egretta garzetta, Charadrius dubius, Ardeola grayji, Halcyon smyrnensis* and *Motacilla alba* were frequently encountered in most of the study lakes.

**Key words**

Abundance, Diversity, Evenness, Seasonal occurrence, Waterbirds

## Introduction

Birds are often common denizens of the ecosystems and they have been considered as an indicator species of inhabited areas (Blair, 1999). Studies showed that depressed abundance of various bird species in most parts of the world today especially in urban areas are of particular concern as many cities are growing rapidly both in area and in population (Emlen, 1974; Donaldson *et al*., 2007). Population of birds is a sensitive indicator of pollution in both terrestrial and aquatic ecosystem (Gaston, 1975; Hardy *et al*. 1987). The estimation of local densities of avifauna helps to understand the abundances of various species of other organisms (Turner, 2003). One of the major priorities in conserving animals is monitoring their populations to find methods for their long term survival (Caughley, 1982).

Wetlands are the most productive and biologically diverse in the world but very fragile ecosystems (Gibbs, 1993). Wetlands and waterbirds are inseparable elements and support a rich array of waterbird communities (Grimmett and Inskipp, 2007). Waterbirds are an important component of most of the wetland ecosystem as they occupy several trophic levels in the food web of wetland nutrient cycles. Activities of waterbirds are considered as indicator of quality of the wetland ecosystem and form the terminal links in many aquatic food chains, and as a result they reflect changes originating in several different ecosystem components (Custer and Osborne, 1977).

Urbanization is a universal phenomenon and its negative effects on biodiversity, especially in terms of irrecoverable habitat fragmentation and loss, extermination of native and migratory species are slowly being understood (Mckinney, 2002). Owing to fast urbanization native species tend to become rare and are restricted to sites that have escaped high intensity development (Godefroid, 2001). Bangalore city is the fifth largest city in India and is also known as the Garden City because of its many beautiful parks, lakes, gardens and natural vegetations. Like many other Indian major cities, industrial and automobile pollutions and habitat destruction are common features in Bangalore city. Despite the fast growth, the

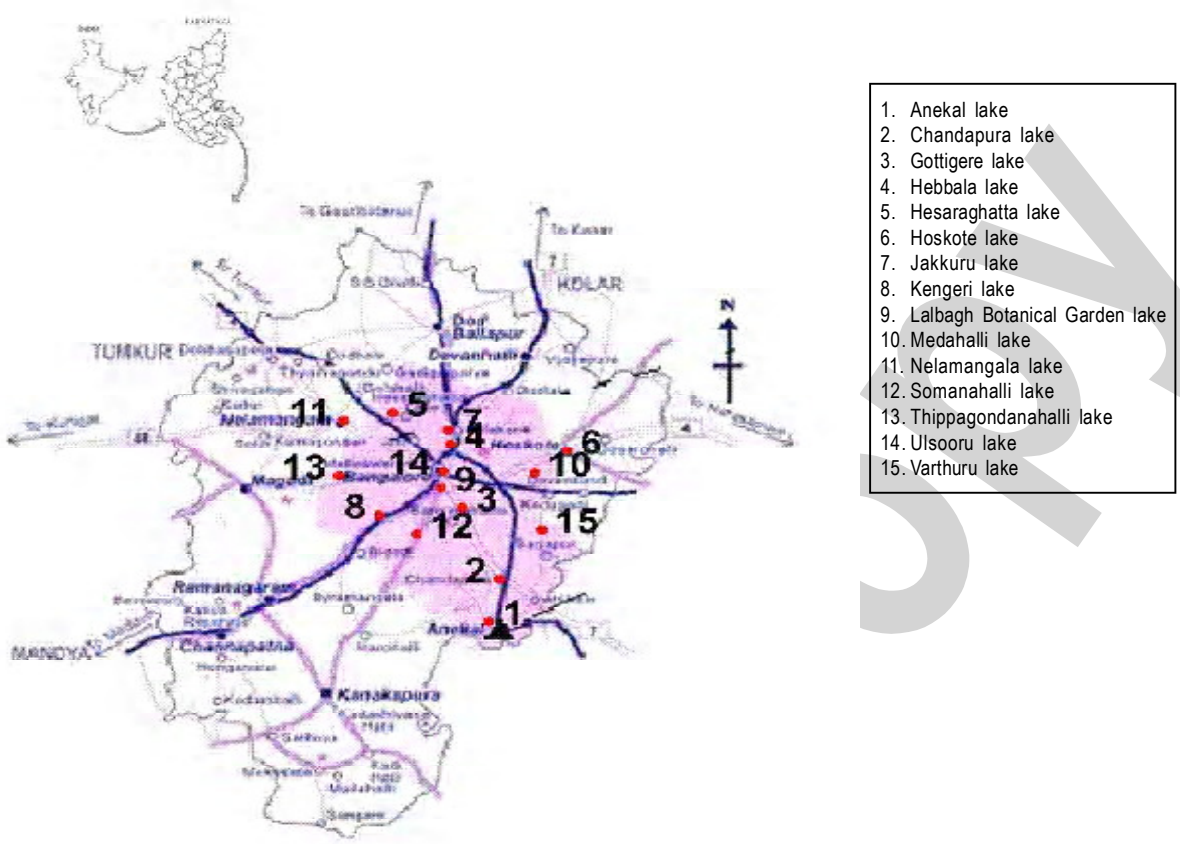


**Fig. 1:** Map of Bangalore showing locations of the study lakes

city has several small to large lakes which are the verdant areas for various species of waterbirds.

The various lakes and wetlands in any city serve as a balancing reservoir for sustaining native flora and fauna (Grimmett and Inskipp, 2007; Surana *et al*., 2007). The aquatic bird communities of the Bangalore region are important bioindicators of lake ecosystems which should be protected to conserve the biodiversity and environment.

Although aquatic bird species in some lakes of Bangalore have been recorded (Manjunath *et al*., 2005), their composition, abundance and diversity have not been thoroughly studied in the major lakes. Hence, we evaluated and compared aquatic avian composition, abundance and diversity in different lakes in Bangalore region.

## Materials and Methods

**Study lakes and surveys:** Bangalore the capital of Karnataka is located in the South Deccan of Peninsular India. Bangalore region lies between latitudinal parallels 12°39' -13°18' N and longitudinal parallels 77°22' -77°52' E at an elevation range 839-962 m above sea level with covering an area of 2191 $km^2$. The temperature ranges between 36 to 14°C, and humidity between 35-80%. It is well known for its equable and salubrious climate. The climate in Bangalore from December to February is cold, March to May is hot, and from June to November is rainy season and the city receives both the southwest and northeast monsoons.

There are several important lakes located in and around the city which attracts varieties of aquatic birds all round the year. The fifteen study lakes and their distance from the central railway station are as follows: Anekal (38 km), Chandapura (26 km), Gottigere (17 km), Hebbala (08 km), Hesaraghatta (28 km), Hoskote (25 km), Jakkuru (12 km), Kengeri (18 km), Lalbagh Botanical Garden Lake (05 km), Medahalli (18 km), Nelamangala (28 km), Somanahalli (22 km), Thippagondanahalli (40 km), Ulsooru (06 km) and Varthuru (34 km) lakes (Fig. 1). These lakes were chosen based on their locations, water level and occurrence of bird populations.

An efficient protocol has been adopted (Turner, 2003). Bird sampling was made by walking at a slow pace (about 1-1.5 km $hr^{-1}$) along the bank of the lakes (as the aquatic birds are usually found around or in the lake) as followed by Gaston (1975) and Bibby *et al*. (2000). However, wherever necessary point count of birds was also made within the visible radius by stopping briefly for 2-3 min as followed by other workers (Froneman *et al*., 2001; Kaul and Howman, 1992; Urfi *et al*., 2005). Birds were counted at their point of first detection and care was taken to ensure that same birds were not counted again. The number of aquatic birds of various species

**Table- 1:** Mean percent frequency, occurrence, residing status and food habits of aquatic birds in the Bangalore region

| Scientific name | Common name | Occurrence status | Mean percent frequency. | Food habit* | Residing status* |
|---|---|---|---|---|---|
| Order: Podicipediformes | | | | | |
| Family: Podicipitidae | | | | | |
| *Tachybaptus ruficollis* | Little grebe | Lc | 54.44 | C/I | R |
| Order: Pelecaniformes | | | | | |
| Family: Pelecanidae | | | | | |
| *Pelecanus onocrotalus* | Rosy pelican | Re | 19.45 | P | RM |
| *Pelecanus philippensis* | Spotted billed pelican | Lc | 46.11 | P | RM |
| Family: Phalacrocoracidae | | | | | |
| *Phalacrocorax carbo* | Large cormorant | Lc | 40.56 | P | RM |
| *Phalacrocorax niger* | Little cormorant | C | 95.00 | P | RM |
| *Anhinga rufa* | Darter bird | Re | 25.00 | P | RM |
| Order: Ciconiiformes | | | | | |
| Family: Ardeidae | | | | | |
| *Ardea goliath* | Giant heron | Re | 22.78 | C | RM |
| *Ardea cinerea* | Grey heron | C | 92.22 | C | RM |
| *Ardea purpurea* | Purple heron | Lc | 35.00 | C | RM |
| *Ardea alba* | Large egret | Lc | 52.22 | C | RM |
| *Ardeola grayji* | Pond heron | C | 76.11 | C/I | R |
| *Bubulcus ibis* | Cattle egret | C | 100.00 | C/I | RM |
| *Egretta intermedia* | Median egret | Lc | 32.22 | C | RM |
| *Egretta garzetta* | Little egret | C | 97.22 | C | R |
| *Nycticorax nycticorax* | Night heron | Re | 21.11 | C/I | R |
| Family: Ciconiidae | | | | | |
| *Mycteria leucocephala* | Painted stork | Lc | 41.67 | C | RM |
| *Anastomus oscitans* | Openbill stork | Re | 23.89 | C/I | R |
| Order: Anseriformes | | | | | |
| Family: Anatidae | | | | | |
| *Anas acuta* | Pintail | Re | 9.44 | H | M |
| *Anas poecilorhyncha* | Spotbill duck | Lc | 56.67 | H | RM |
| *Anas platyrhynchos* | Mallard | Re | 4.44 | H | RM |
| *Anas querquedula* | Garganey teal | C | 80.55 | H | M |
| *Anas clypeata* | Shoveller | Re | 6.67 | C | M |
| Order: Gruiformes | | | | | |
| Family: Rallidae | | | | | |
| *Porphyrio porphyrio* | Purple moorhen | Lc | 32.78 | O | R |
| *Fulica atra* | Coot | C | 92.78 | O | RM |
| Oder: Charadriiformes | | | | | |
| Family: Charadridae | | | | | |
| *Vanellus indicus* | Redwattled lapwing | Lc | 38.89 | C/I | R |
| *Charadrius dubius* | Little ringed plover | C | 68.33 | C/I | RM |
| Family: Scolopacidae | | | | | |
| *Tringa nebularia* | Greenshank | Lc | 30.55 | C/I | M |
| *Tringa hypoleucos* | Common sandpiper | C | 93.33 | C/I | RM |
| Oder: Coraciiformes | | | | | |
| Family: Alcedinidae | | | | | |
| *Ceryle rudis* | Pied kingfisher | C | 75.00 | P/I | R |
| *Alcedo atthis* | Small blue kingfisher | C | 81.67 | P/I | RM |
| *Halcyon smyrnensis* | Whitebreasted kingfisher | C | 89.45 | C/I | R |
| Order: Passeriformes | | | | | |
| Family: Motacillidae | | | | | |
| *Motacilla flava* | Yellowwagtail | C | 60.56 | I | RM |
| *Motacilla cinerea* | Grey wagtail | C | 80.00 | I | M |
| *Motacilla alba* | White wagtail | C | 56.69 | I | RM |
| *Motacilla maderaspatensis* | Largepied wagtail | C | 99.44 | I | R |

* = Ali, 1996; M = Migrant, R = Resident, RM = Resident Migrant; C = Carnivorous, H = Herbivorous, I = Insectivorous, O = Omnivorous, P = Piscivorous 0–25% = Re (Rare), 26–65% = Lc (Less common), 66–100% = C (Common)

was recorded in a data sheet at each sampling lake on each census day. Call notes of the birds were used for identification. Counting of the birds was made in the morning between 07:30 and 10:30 hr or in the afternoon between 15:00 and 18:00 hr, depending on the light conditions (Namgail *et al.,* 2009). Recordings were not made at the time of heavy rains. Surveys were conducted once a fortnight in the identified lakes during February 2008 - January 2009. The check list of species was prepared following Ali (1996), Manakadan and Pittie (2001) and Grimmett and Inskipp (2007). Joshua and Johnsingh (1988) have classified the bird populations as rare, frequently seen and common based on the number of sightings, and abundance. Similarly, based on the percent frequency of occurrence of bird species, we have classified the scores as 0-25% as rare (Re), 26-65% as less common (Lc), and 66-100% as common (C).

**Data analysis:** Evenness, Shanon-Weiner diversity and Marglef's richness indices were estimated using the computer program PAST version 1.60 software (Hammer *et al*., 2001). The percent abundance and percent frequency of bird species were also calculated. The difference in diversity and evenness indices of aquatic birds among different study lakes were statistically analyzed using analysis of variance. Cluster analysis was carried out to create a dendrogram to assess the similarity in number of waterbird species composition among the study lakes using Biodiversity Pro Version 2 (McAleece *et al*., 1997).

## Results and Discussion

The occurrence, percent frequency, ecological status and food sources of different species of aquatic birds recorded at 15 study lakes in the Bangalore region are given in Table 1. We recorded 35 species of aquatic birds belong to 11 families under eight orders. However, Manjunath *et al*. (2005) recorded 42 species of waterbirds in the lakes of north Bangalore, which includes all the present 35 species. Some of the common waterbirds such as *Bubulcus ibis*, *Tachybaptus ruficollis*, *Egretta garzetta*, *Ardeola grayji* and *Porphyrio porphyrio* recorded in the lakes were also recorded as commonly occurring birds in the wetland agro-ecosystems of maiden area of Karnataka (Basavarajappa, 2006). Maximum number of species were belong to Ardeidae (9) followed by Anatidae (5), Motacillidae (4), Alcedinidae and Phalacrocoracidae (3 each), Charadridae, Ciconiidae, Pelecanidae, Rallidae and Scolopacidae (2 each), and Podicipitidae (1). Of the various recorded waterbird species, only 19 species were found in all the study lakes.

Of the 35 aquatic bird species, 10 species were carnivorous/ insectivorous, 8-carnivorous, 5-piscivorous, 4- insectivorous, 4-herbivorous, 2-omnivorous, and 2- piscivorous/insectivorous. Feeding habit and residing status of individual bird species are as reported by Ali (1996) (Table 1). Similarly, of the 35 recorded

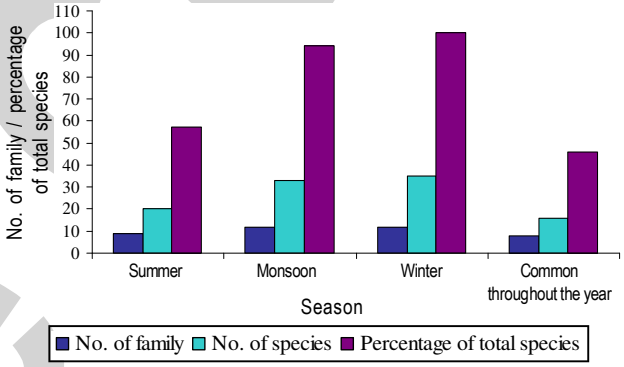


**Fig. 2:** Seasonal variations of water birds of Bangalore lakes

**Table – 2:** Mean percent abundance, Shannon-Weiner diversity, Margalef's richness and species evenness of aquatic birds in different lakes in the Bangalore region

| Lake | No. of species | Mean % Abundance[a] | Shannon-Weiner diversity[b] | Evenness[c] | Margalef's species richness[d] |
|---|---|---|---|---|---|
| Anekal lake | 30 | 6.56 | 2.93 | 0.62 | 3.38 |
| Chandapura lake | 31 | 4.77 | 3.15 | 0.75 | 3.63 |
| Gottigere lake | 31 | 3.79 | 3.10 | 0.72 | 3.73 |
| Hebbala lake | 34 | 9.97 | 2.89 | 0.53 | 3.66 |
| Hesaraghatta lake | 30 | 3.20 | 2.94 | 0.63 | 3.68 |
| Hoskote lake | 33 | 11.17 | 2.16 | 0.26 | 3.51 |
| Jakkuru lake | 32 | 4.62 | 3.14 | 0.72 | 3.76 |
| Kengeri lake | 32 | 5.41 | 3.04 | 0.65 | 3.69 |
| Lalbagh botanical garden lake | 34 | 4.58 | 3.16 | 0.69 | 4.01 |
| Medahalli lake | 35 | 21.49 | 2.43 | 0.32 | 3.48 |
| Nelamangala lake | 31 | 4.61 | 3.12 | 0.73 | 3.64 |
| Somanahalli lake | 24 | 2.70 | 2.90 | 0.76 | 2.99 |
| Thippagondanahalli lake | 30 | 4.63 | 2.86 | 0.58 | 3.52 |
| Ulsooru lake | 23 | 2.46 | 2.07 | 0.34 | 2.89 |
| Varthuru lake | 32 | 10.04 | 2.95 | 0.60 | 3.44 |

[a] = Mean percent abundance of aquatic bird populations was significantly different ($F=31.413$, $df=14$, $p<0.05$); [b] = Diversity values of aquatic bird populations was significantly different ($F=8.191$, $df=14$, $p<0.05$); [c] = Species evenness among study lakes in different locations was significantly different ($F=17.274$, $df=14$, $p<0.05$); [d] Species richness among study lakes was significantly not different ($F=1.412$, $df=14$, $p>0.05$)

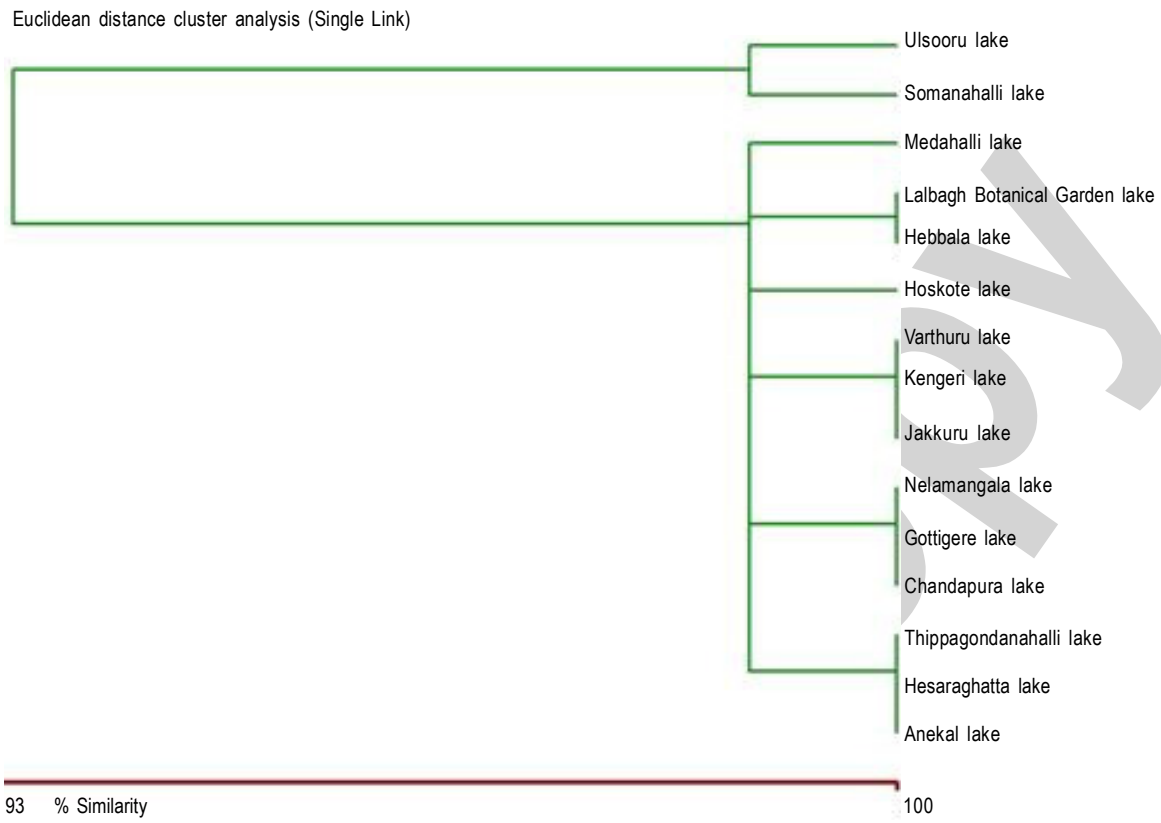


**Fig. 3:** Dendrogram showing similarity in number of water bird species of Bangalore lakes

species, 20, 10 and 5 species were resident migrants, pure resident and pure migrants, respectively. Similar pattern of occurrence of waterbirds also recorded in Mayurbhanj district, Orissa (Shahu and Rout, 2005) and Didwana Inland Saline Lake, Nagaur, Rajasthan in India (Bhatnagar *et al*., 2008).

Of the various recorded waterbird species, *Bubulcus ibis* showed cent percent frequency, whereas *Anas platyrhynchos* was less frequently (4.44) observed. Based on percent frequency of occurrence of waterbirds in the lakes, eight species were considered as rare, 11- less common and 16- common. The percent frequency of occurrence of each waterbird species is given in Table 1. The mean percent abundance (21.49) of waterbirds at Medahalli lake was highest, whereas lowest abundance (2.46%) of the birds was from Ulsooru lake (Table 2). There was a significant difference ($F=31.413$, $df=14$, $p<0.05$) in abundance of birds among various lakes. Number of waterbird species recorded in 15 lakes ranged from 23 to 35. The highest number of species (35) was recorded in Medahalli lake, which has more number of trees/bushes around the lake and located in the outskirt of the city, whereas the lowest number (23) of species was found in Ulsooru lake, which is located within the busy city limit. The low abundance and less number of species of birds in Ulsooru lake could be due to various reasons such as the public boating activities in the lake, heavy vehicular traffic around the lake, anthropogenic activities for instance morning and evening walking/resting around the lake and disturbance caused due to military parade in the vicinity of the lake locality.

Diversity of waterbirds in various lakes ranged from 2.07 to 3.16. The highest diversity (3.16) of waterbirds was recorded at Lalbagh Botanical Garden lake, which is well maintained and protected, whereas the lowest bird diversity (2.07) was observed in Ulsooru lake, which is located in the disturbed area as mentioned above (Table 2). There was a significant difference ($F=8.191$, $df=14$, $p<0.05$) in diversity among various lakes. The varying diversity of the birds in different lakes could be due to differing habitat conditions for roosting/nesting/feeding and availability of food sources.

The highest species evenness (0.76) was observed in Somanahalli lake, whereas the lowest evenness of species (0.32) was from Medahalli lake (Table 2). There was a significant difference ($F=17.274$, $df=14$, $p<0.05$) in species evenness among different lakes. The Margalef's species richness was highest in Lalbagh Botanical Garden lake (4.01), whereas lowest in Ulsooru lake (2.89) (Table. 2) and it was not significantly different ($F=1.412$, $df=14$, $p>0.05$).

The number of waterbird species observed in summer was 20 (57.14% of total species), which increased up to 33 (94.29%) in monsoon and 35 (100%) in winter. However, 16 species (45.71%) were common throughout the year (Fig. 2). The number of waterbird species was highest in winter compared to the other seasons due to the arrival of migratory birds. The more number of birds were recorded when lakes were full during monsoon and winter periods, while in summer with drying lakes abundance of waterbirds

decreased. Similar kind of varying waterbird population in relation to water level and season has been reported in lakes of Dudwa National Park, India (Maheshwaran and Rahmani, 2001).

Dendrogram showing similarity in the number of waterbird species among 15 lakes, Somanahalli and Ulsooru lakes which accounted for less number of waterbird species belong to one cluster, whereas rest of the 13 lakes with moderate to maximum number of species formed another cluster. These two major clusters show significant negative affinities (Fig. 3).

*Eichhornia crassipes* was a major weed spread across in most of the study lakes. Similarly, *Alternanthera philoxeroides* and *Alternanthera sessils* of the wetlands were found on the bunds of most of the lakes. The other species of weeds such as *Amaranthus spinosus, Aponogeten natans, Bacopa monnieri, Calotropis gigantean*, *Calotropis procera*, *Celosia argentea*, *Colocasia esculenta*, *Cyperus articulatus*, *Evolvulus alsinoides*, *Hydrilla verticillata, Ipomoea aquatica, Nelumbo nucifera*, *Nymphaea spp.*, *Ottelia alismoides*, *Oxalis sp.*, *Pistia spp.*, *Polygonum* sp., *Ricinus communis*, *Typa angustata* and *Vallisneria spiralis* were usually present in/around some of the lakes except Hesaraghatta, Somanahalli, Thippagondanahalli and Ulsooru lakes. The aquatic weeds are absent in Hesaraghatta and Thippagondanahalli lakes as they are well maintained natural reservoirs for supplying of drinking water to Bangalore city. Similarly, Somanahalli lake is used by villagers and Ulsooru lake is maintained by Lake Development Authority. The many aquatic weeds in addition to the major hazardous growth of water hyacinth recorded in most of the lakes were found to decrease the lake area as reported in Udaipur, Rajasthan (Bhatnagar *et al*., 2007). It was observed that the various decaying weeds in the lakes formed floating vegetation islands/mats which deteriorate habitat quality and also interfere with foraging activities of waterbirds as observed by Bhatnagar *et al*. (2007). Furthermore, nests of any birds were not found in these weeds. Mukherjee *et al*. (2002) reported that aquatic weeds and short vegetations are not suitable for nesting. In addition to the weeds, other factors affecting the waterbird populations in the various lakes were fishing and mushrooming of aquaculture farms. Similar kinds of activities are known to affect the waterbird populations in Pulicat Lake, Andhra Pradesh, India (Raghavaiah and Davidar, 2007).

The activities of terrestrial birds such as *Acridotheres fuscus*, *Acridotheres tristis*, *Corvus macrorhynchos, Corvus splendens* and *Milvus migrans* around the study lakes were not found interfering with the activities of aquatic birds.

From the aforesaid results it could be made out that the availability of water, safe habitat and food sources for both adults and nestlings and essential nesting/roosting sites in and around the lakes are important for the occurrence and abundance of aquatic bird populations. As water depth, quality and trophic structure are the important habitat characteristics that influence the abundance and diversity of aquatic birds in lakes, the proper and regular maintenance of Bangalore lakes would further increase the aquatic bird populations. The results of this study will help to conserve waterbird populations in urban regions.

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