

Avifauna of Kukkarahalli Tank: Decline of species due to impact of ‘restoration’ work

M. K. Sapthagirish, Sukhprit Kaur & Honnavalli N. Kumara

Sapthagirish, M. K., Kaur, S., & Kumara, H. N., 2015. Avifauna of Kukkarahalli Tank: Decline of species due to impact of ‘restoration’ work. *Indian BIRDS* 10 (6): 141–146.

M. K. Sapthagirish, # F/34, New Sayyaji Rao Road, Fort Mohalla, Mysore 560004, Karnataka, India.

Sukhprit Kaur, Centre for Environment Education South 143, Kamala Mansion, Infantry road, Bengaluru 570001, Karnataka, India.

Honnavalli N. Kumara, Sálím Ali Centre for Ornithology and Natural History, Anaikatty P.O., Coimbatore 641108, Tamil Nadu, India.

E-mail: honnavallik@gmail.com [Corresponding author]

Manuscript received on 10 July 2012.

Abstract

Urban wetlands are, potentially, important bird habitats, but the impact that developmental activities around wetlands, directed at improving tourism, have on local bird diversity is poorly understood. Kukkarahalli Tank offers a unique opportunity to assess this. A checklist of birds of the area was completed in 1997, but development activities were completed during 2002–2004. We conducted bird surveys during 1999–2000 and 2006–2007, and compare the results with the 1997 checklist to understand if species richness, and number of breeding species, varied. 120 bird species were recorded in 1999–2000, and 104 during 2006–2007. The study results show a steep decline in avian species richness (41%), along with the displacement of several breeding species (32%), including those of conservation concern such as Spot-billed Pelican, Painted Stork, and Black-headed Ibis. The decline in diversity and breeding activities in the tank is attributed to the structural changes in the wetland ecosystem. This study provides strong evidence for the need for an ecological approach in other urban wetlands where planning to improve visitation rates are being made. Such planning can help limit the loss of important biodiversity that may already be using these wetlands.

Introduction

Wetlands are one of the most diverse ecosystems on the planet, sustaining high species richness (Dugan 1990; Gibbs 2000; Sridhar *et al.* 2000). Lakes and tanks are the major inland wetlands persisting in urban areas and have been considered ecological security zones, and indicators of sustainable urban development (Gibbs 2000; Saunders *et al.* 2002). Urbanisation is responsible for biodiversity loss, and biological homogenisation, in many countries (Pauchard *et al.* 2006). Urbanisation that does not incorporate natural resource management and preservation has led to the decline of wetlands in cities due to encroachment for building constructions, and conversion to dump sites for solid wastes and sewage. Additionally, pollution via sewage and industrial effluents has caused increased eutrophication, causing deterioration in the quality of wetland habitats (Foote *et al.* 1996; Bedford 1999).

India has an estimated wetland cover of ~58.2 million ha (Directory of Indian wetlands: Anonymous 1993), which supports a huge biodiversity. Healthy wetlands are essential for the sustenance of India's diverse populations of plants and animals, and they support a large number of wetland-dependent endemic species. Thousands of such wetlands are biologically important, but very few are brought under the umbrella of “protected area network”. Only 25 wetland sites in India are protected under the Ramsar Convention (Wetlands of India 2009), and some are designated as Important Bird Areas (IBA) under the Indian Bird Conservation Network (IBCN 2009). Karnataka State has about 11,024 inland water bodies (National Wetland Atlas 2010) of which only 36, including Kukkarahalli Tank, have been designated as IBAs (IBCN 2009).

Kukkarahalli Tank is situated in the heart of Mysore city and its birdlife has been well documented (Guruprasad 1997).

Over the years, the tank has faced continuous developmental pressures, but the impacts of these pressures are poorly understood (Guruprasad 1997; Ravikumar *et al.* 1999). Earlier, the Mysore Amateur Naturalists (MAN), a local non-government organisation, published a comprehensive avifaunal checklist of Kukkarahalli Tank, which was compiled over a period ten years (1987–1997), and reported 180 species (Guruprasad 1997). To assess whether the on going development activities had an impact on the birds, we monitored the species richness, and abundance, of birds from September 1999 to September 2000, and from December 2006 to November 2007. We hoped the results of our study would help guide future development plans of wetlands, especially those in urban areas. In our study we focus particularly on the changes in species assemblages. We also use the opportunity to underscore the importance of persisting urban wetland bodies like Kukkarahalli Tank.

Materials & methods

Study site

The Kukkarahalli Tank (12.30°N, 78.63°E; 760 m asl; Fig. 1) in Mysore, Karnataka, receives both, the south–western, and the north-east monsoons, with an average rainfall of 782 mm (Anonymous 2015; National Wetland Atlas 2010). At full tank level its water spread is ~0.39 sq. km, and maximum depth c. 08 m. On its western edge lie a horticulture seed centre, a teachers training centre, and an abandoned coffee plantation; a marshy stretch, overgrown with water hyacinth *Eichornia crassipes*, and grass species such as *Typha*, marks its northern edge. Large plantations of teak *Tectona grandis*, eucalyptus *Eucalyptus grandis*, and acacia species, interspersed with bamboo *Bambusa arundinaria*, lantana *Lantana camara*, and many shrub / weed



Fig. 1. Map of the Kukkarahalli Tank [Not to scale].

- (a) The bold green line indicates the jogging/walking path prior to development works.
 (b) The Dotted green line shows the post development work were in the extension of the jogging/walking path all around the tank.
 (c) Dotted red line indicates the proposed shifting of jogging/walking path.

species e.g., *Parthenium hysterophorus*, and *Euphorbia* species mark the well-wooded eastern side of the tank. The southern side has a jogging track on the upper end of the slope. The tank has an island, overgrown with acacia trees that provide roosting and nesting sites for many birds. However, the nesting birds' acidic droppings do not allow any undergrowth, which has resulted in erosion; the water even breaching it at certain points. Two boat jetties, on the eastern, and southern sides, are used by fishermen.

Kukkarahalli Tank was built in 1864, to provide drinking water to Mysore city, and came under the custody of the University of Mysore in 1960. The original catchment area of the tank was ~4.5 sq km. (Guruprasad 1997; Ravikumar *et al.* 1999). Expansion of the city led to the blockage of all feeder canals; urban sewage inflows becoming the main source of water. To control the putrefaction due to sewage water accumulation, tank restoration was initiated in 2002 with financial support from the Asian Development Bank. Walking pathways were laid around the periphery of the tank to encourage public recreation; some shrubs and trees on the bund, and along the periphery of the lake, were removed to accommodate these new paths. This has resulted in previously inaccessible areas of the tank now becoming accessible.

Data collection

We conducted systematic surveys of birds in Kukkarahalli Tank from September 1999 to September 2000 and from December 2006 to November 2007. The rainfall during this period was 866.2 mm, and 836.3 mm respectively, while the rainfall during 1996–1997 was 1156.8 mm (Yogananda *et al.* 2015). However,

during our survey the water level in the tank remained constant as its major source is the sewage influx from the surrounding areas (from last two decades). The 'total count method' was employed for water birds. The 'encounter method' was used to monitor the non-wetland birds along two 1.2 km transects on the shore of the tank, including the vegetated area. During 1999–2000, the transects were walked during 0600–1000 hrs (N=21), 1100–1400 hrs (N=11), and 1600–1800 hrs (N=5). In 2006–2007 this was during 0600–1000 hrs (N=20), 1100–1400 hrs (N=5), and 1600–1800 hrs (N=5). The transect walks were spread out during the day to ascertain different species of birds utilising the tank during the daytime. The status of birds was ascertained based

on frequency of sightings, and sightings across the study period. We categorised them in the following manner: Very common (VC) when a species was recorded on 75–100% transects, or throughout the study period; Common (C) recorded on 50–75% transects; uncommon (UC) recorded on 25–50% transects; rare (R) recorded on <25% transects; very rare (VR) <5 individual sightings; and absent (AB) when sightings were zero. Birds were classified as Resident (r), winter visitor (W), and Visitor (V). The various ways in which birds used the tank were categorised as: Roost (Ro), forage (Fo), and breed (B).

We collated the data from all our transects to arrive at the numbers of species, and hatchlings of certain water birds, and the abundance of three breeding birds: Spot-billed Pelican *Pelecanus philippensis*, Painted Stork *Mycteria leucocephala*, and Black-headed Ibis *Threskiornis melanocephalus*, listed as Near Threatened (BirdLife International 2015; IUCN 2015). We compared the results of our study with Guruprasad's checklist (1997) to determine if bird communities changed over this period. To analyse any variations in species richness consequent to artificial manipulation of the tank, we classified the birds according to their habitat preferences into different guilds, namely, wetland guild (wetland birds), woodland guild (birds recorded in the wooded area), and others, which includes birds of the bush, and open lands.

Results & discussion

Species diversity

Appendix 1 summarises the occurrence and status of birds at Kukkarahalli Tank over three study periods. Guruprasad (1997) reported a total of 180 bird species, while we recorded 120 in 1999–2000, and 104 in 2006–2007—a significant decline in species richness (41%) in the decade 1998–2007 ($\chi^2=51.43$, $df=2$, $p<0.01$; Fig. 2). Likewise, the number of breeding species declined by 32% during the decade ($\chi^2=7.17$, $df=2$, $p<0.05$;

Fig. 2). The decline by guild, for this decade, was: wetland birds—37%, woodland birds—23.8%, and others—39% (Fig. 3).

Since the tank harboured a large number of wetland birds, data relating to them were analysed to understand changes in their diversity over the study period. Guruprasad (1997) had reported 62 species of wetland birds, of which 25 were recorded breeding. In comparison, we recorded 40 species in 1999–2000, of which 17 were breeding, and 39 in 2006–2007, of which 14 were breeding (Fig. 4). The number of wetland birds ($\chi^2=16.34$, $df=2$, $p<0.01$) and the number of breeding species ($\chi^2=7.40$, $df=2$, $p<0.05$), between the three study periods, were significantly different. A decline of 37% of wetland bird species and 44% of breeding bird species of wetland was recorded.

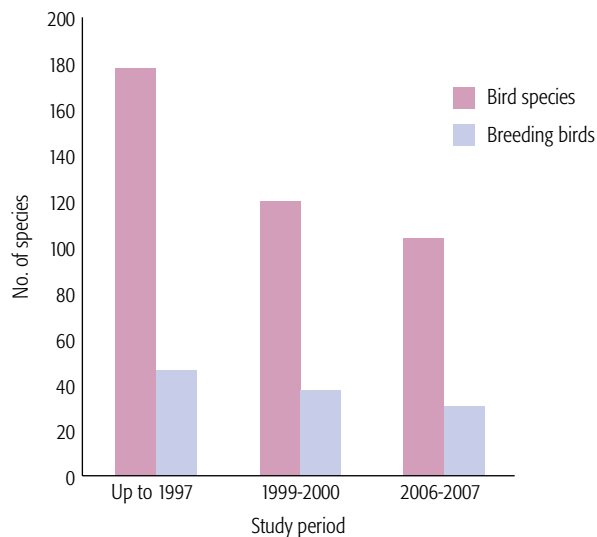


Fig. 2. Number of bird species and breeding birds in Kukkarahalli Tank between different study periods.

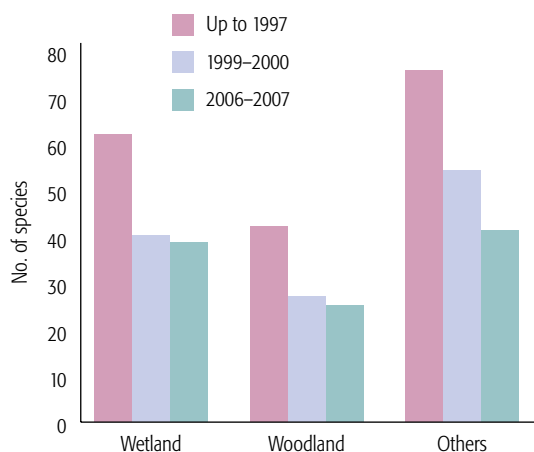


Fig. 3. Various guilds showing declines in bird richness over three-study periods i.e., up to 1997, 1999–2000, and 2006–2007.

Comparison of breeding species

Painted Storks and Spot-billed Pelicans were seen in large numbers between winter and summer (January to May) of both the study periods. Black-headed Ibis arrived at the tank in March, their numbers increasing greatly in June. During 1999–2000 all three species were successfully breeding and had raised nestlings.

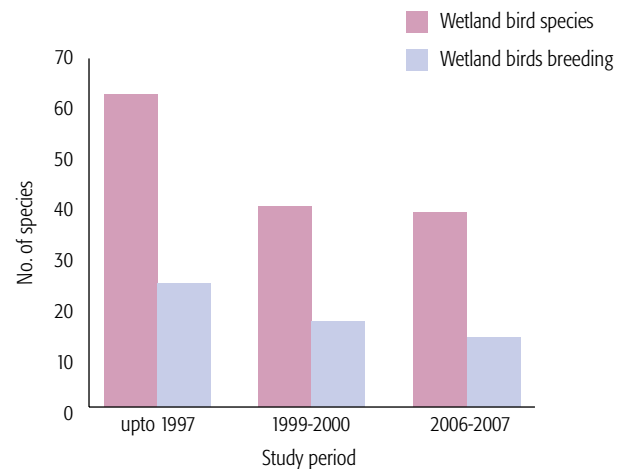


Fig. 4. Numbers of wetland bird species, and wetland birds breeding in Kukkarahalli Tank during different study periods.

The population status of adults and hatchlings for the periods 1999–2000, and 2006–2007, are shown in Fig. 5. However, in 2006–2007 only Painted Storks were seen with their hatchlings. The Spot-billed Pelican numbers soared to 180 in March 2007, when we observed some nest building activity; but these were later found abandoned. Black-headed Ibis started arriving to the tank in March 2007; however they did not nest due to loss of their regular nesting area, and only a few birds roosted on the island. A maximum of 60 birds were recorded for 2006–2007 as compared to 286 during 1999–2000 (Fig. 5).

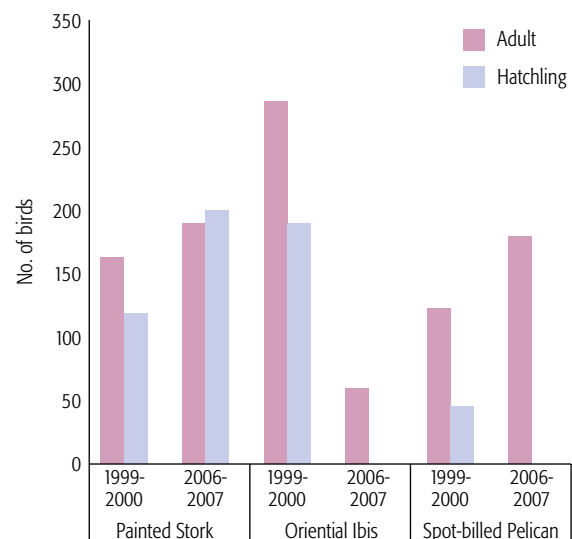


Fig. 5. Numbers of Painted Stork, Oriental White Ibis, and Spot-billed Pelican adults, and hatchlings during three study periods.

New sightings

During our study, three species were added to Guruprasad's (1997) checklist of Kukkarahalli Tank, namely, Crested Serpent Eagle *Spilornis cheela*, Oriental Honey Buzzard *Pernis ptilorhynchus*, and Woolly-necked Stork *Ciconia episcopus*. These birds were extremely rare at the tank, Crested Serpent Eagle and Woolly-necked Stork were sighted only once, and Oriental Honey Buzzard was sighted twice.

Development activities and their impact

Development is invariably associated with the loss of many avian species, particularly habitat specialists (Chace & Walsh 2006; Clergeau *et al.* 2006; McKinney 2006). It has been observed that the influence of human presence in urban areas decreases the breeding densities of birds (Evans *et al.* 2009). It is believed that many birds perceive humans as potential predators and respond in a way that leads to limiting their use of resources, such as nesting sites or food (McKinney 2006; Gill 2007; Holm & Laursen 2009). The breeding status, and diversity, of birds in Kukkarahalli Tank are directly influenced by the the large crowds of people who use the tank site for jogging and walking during the day.

Kukkarahalli Tank, which was an important site for many birds, including a few migrants, is witnessing a decline in their numbers. Many birds, which bred here earlier, have either stopped breeding, or are completely absent from the area. Though some species adaptive and co-exist with people, many bird species are very sensitive to changes in their habitat, and to human presence (Daniels 2008). Rampant developmental activities around the tank, in recent times, and 'human-centric' tank bund restorative works have led to considerable structural changes in the ecosystem of the tank, which in turn has affected the diversity, density, and breeding activities of the avifauna in the area.

During the post restoration study that was conducted in 2006–2007, Spot-billed Pelicans were observed constructing nests, which they ultimately abandoned. Black-headed Ibis, which started arriving in March 2007 were unable to settle down easily at their regular breeding sites in the tank, and didn't breed that year.

The increase of recreational activities (walking / jogging with loud music) was the likely reason that birds abandoned nesting here. Further, in order to appeal to the aesthetic sense of the people, trimming of bushes and reeds has become a routine management activity; this has brought down the number of bush-nesters like prinias and munias, and reed-nesters like Purple Swamphen *Porphyrio porphyrio*, Common Moorhen *Gallinula chloropus*, and Common Coot *Fulica atra*. Also many ground birds like the Eurasian Thick-knee *Burhinus oedicnemus*, and Yellow-wattled Lapwing *Vanellus malabaricus*, which have bred earlier here, are not seen now. Clearly, the increased number of people has had apparent effects on bird species richness and behaviour, and may even cause the permanent displacement of species from this site.

The following management activities are suggested to help improve conditions for birds that use Kukkarahalli Tank.

- a. The perambulatory path, which criss-crosses the woodland, and the northern bund, could be shifted away from the tank, closer to the boundary wall (Fig. 1: dotted red lines).
- b. Fishing and any human presence near the breeding sites should be minimised during the peak breeding seasons.
- c. Routine clearing of bushes and reeds has to be regulated in an eco-friendly way with inputs from the conservationists and ecologists.
- d. Ecologists/conservationists should be involved in the developmental activities, and management of the tank.
- e. Imparting ecological value of birds to the public, through environmental education, can help minimize disturbance during the breeding season.

Acknowledgements

We would like to express our sincere gratitude to Mewa Singh, for providing us constant support and encouragement all through the study period, and G. Krishna for helping us with the plant identifications. We acknowledge A. Shivaprakash, A. K. Sharma, and M. A. Kumar for useful discussions, and Sindhu Radhakrishna for helping us in completing this manuscript. We are grateful to M. B. Krishna, and S. Karthikeyan for providing valuable comments on earlier versions of the manuscript. We are grateful to Thirumalainathan for reviewing our manuscript and giving us valuable inputs and improving the manuscript. We would also like to thank Sunil R. Sonale, and Dorjee for helping us with the fieldwork.

References

- Anonymous. 1993. Directory of Indian wetlands, 1993. Pp. 1–263. World Wildlife Fund: New Delhi.
- Anonymous. 2015. Mysore District. Website URL: <http://www.mysore.nic.in/geography.htm> [Accessed on 20 October 2015.]
- Bedford, B. L., 1999. Cumulative effects on wetland landscapes: Links to wetland restoration in the United States and Southern Cannada. *Wetlands* 19: 775–788.
- BirdLife International. 2015. *BirdLife's online World Bird Database: the site for bird conservation*. Version 2.1. Cambridge, UK: BirdLife International. Available: <http://www.birdlife.org/>. [Accessed on 12 June 2015.]
- Chace, J. F., & Walsh, J. J., 2006. Urban effects on native avifauna: a review. *Landscape and Urban Plan* 74: 46–49.
- Clergeau, P., Croci, S., Jokimaki, J., Kaisanlahti, Jokimaki, M. L., & Dinetti, M., 2006. Avifauna homogenisation by urbanisation: Analysis at different European latitudes. *Biological Conservation* 127: 336–344.
- Daniels, R. J. R., 2008. Can we save the sparrow? *Current Science* 95: 1527–1528.
- Dugan, J. P., (ed.) 1990. *Wetland conservation: a review of current issues and required action*. IUCN, Gland, Switzerland. Pp. 1–96.
- Evans, K. L., Newson, E. S., & Gaston, K. J., 2009. Habitat influences on urban avian assemblages. *Ibis* 151: 19–39.
- Gibbs, P. J., 2000. Wetland loss and biodiversity conservation. *Conservation Biology* 14: 314–317.
- Gill, J. A., 2007. Approaches to measuring the effects of human disturbance on birds. *Ibis* 149: 9–14.
- Guruprasad, P., 1997. *Check List of the Birds of Kukkarahalli Lake*. 1st ed. Mysore: Mysore Amateur Naturalists. Pp. 1–36.
- Holm, T. E. & Laursen, K., 2009. Experimental disturbance by walkers affects behavior and territory density of nesting Black-tailed Godwit *Limosa limosa*. *Ibis* 151: 77–87.
- IBC 2009. Website URL: http://www.ibcn.in/IBAS_india.asp/. [Accessed on 16 June 2009.]
- IUCN 2015. Website URL: http://www.iucn.org/about/work/programmes/species/red_list/. [Accessed on 24 June 2015.]
- Foote, A. L., Pandey, S., & Krogman, N. T., 1996. Processes of wetland loss in India. *Environmental Conservation* 23: 45–54.
- McKinney, M. L., 2006. Urbanization as a major cause of biotic homogenization. *Biological Conservation* 127: 247–260.
- National Wetland Atlas. 2010. Karnataka, SAC/EPSA/AFEG/NWIA/ATLAS/30/2010, Space applications center ISRO, Ahmedabad, India 204.
- Pauchard, A., Aguayo, M., Pena, E., & Urrutia, R., 2006. Multiple effects of urbanization on the biodiversity of developing countries: The case of a fast growing metropolitan area Concepcion, Chile. *Biological Conservation* 127: 272–281.
- Ravikumar, U. N., Sadananda, K. B., & Guruprasad, P., 1999. *A comprehensive plan for conservation of Kukkarahalli lake*. Centre for Appropriate Rural Technologies, The National Institute of Engineering, Mysore.
- Saunders, D. L., Meeuwij, J. J., & Vincent, A. C. J., 2002. Freshwater protected areas: Strategies for conservation. *Conservation Biology* 16: 30–41.
- Sridhar, S., Chakaravathy, A. K., & Chakrapani, B. K., 2000. *An overview of conservation strategies and suggestions for restoration of wetlands in Karnataka*, Lake 2000—The International Symposium on 'Restoration of lakes and wetlands' organized by Centre for Ecological sciences, Indian Institute of Science. Pp. 54–62.
- Yogananda, S. B., Shruthi, G. K., & Thimme Gowda, P., 2015. Rainfall trend analysis of Mysore district in Karnataka. *International Journal of Recent Research in Interdisciplinary Sciences* 2 :11-15.
- Wetlands of India. 2009. Website URL: <http://www.wetlandsofindia.org/wetlands/intram.jsp/> [Accessed on 29 June 2009, but now not working. An alternate website for the data is: <http://www.ramsar.org/sites-countries/the-ramsar-sites> (Accessed in 20 October 2015.)]

Appendix 1. Birds at Kukkarahalli Tank recorded during three different time periods (up to 1997: Guruprasad, P. 1997*; 1999-2000 and 2006-2007: current study)

S. No.	Species	Up to 1997	1999-2000	2006-2007
1	Lesser Whistling Duck <i>Dendrocygna javanica</i>	VC/r/V/B	C/V/ Ro/Fo	C/V/ Ro/Fo
2	Common Pochard <i>Aythya ferina</i>	R/W	AB	AB
3	Garganey <i>Spatula querquedula</i>	VC/W	C/W/Ro/Fo	C/W/Ro/Fo
4	Northern Shoveler <i>Spatula clypeata</i>	UC/W	AB	AB
5	Indian Spot-billed Duck <i>Anas poecilorhyncha</i>	VC/r/B	VC/r/Ro/Fo/B	VC/r/Ro/Fo/B
6	Northern Pintail <i>Anas acuta</i>	UC/W	AB	AB
7	Common Teal <i>Anas crecca</i>	UC/W	AB	AB
8	Comb Duck <i>Sarkidiornis melanotos</i>	VR/W	AB	AB
9	Cotton Teal <i>Nettapus coromandelianus</i>	UC/W	AB	AB
10	Quail sp. <i>Coturnix</i> sp.	R/r	AB	AB
11	Grey Francolin <i>Francolinus pondicerianus</i>	C/r/B	C/r/Fo/Ro/B	C/r/Fo/Ro/B
12	Little Grebe <i>Tachybaptus ruficollis</i>	VC/r/B	VC/r/ Ro/Fo /B	VC/r/ Ro/Fo /B
13	Rock Pigeon <i>Columba livia</i>	UC/V	VC/Fo	VC/Fo
14	Eurasian Collared Dove <i>Streptopelia decaocto</i>	C/r	AB	AB
15	Spotted Dove <i>Streptopelia chinensis</i>	C/r/B	C/r/Fo/Ro/B	C/r/Fo/Ro/B
16	Laughing Dove <i>Streptopelia senegalensis</i>	NR	VR/V	AB
17	Indian Nightjar <i>Caprimulgus asiaticus</i>	R/r	R	R
18	Asian Palm Swift <i>Cypsiurus balasienis</i>	UC/V	UC/V/Fo	UC/V/Fo
19	Indian House Swift <i>Apus affinis</i>	C/V	C/V/Fo	C/V/Fo
20	Greater Coucal <i>Centropus sinensis</i>	VC/r	VC/r/Fo/Ro	VC/r/Fo/Ro
21	Pied Cuckoo <i>Clamator jacobinus</i>	UC/V	AB	AB
22	Asian Koel <i>Eudynamis scolopacea</i>	C/r/B	C/r/Fo/Ro/B	C/r/Fo/Ro/B
23	Indian Cuckoo <i>Cuculus micropterus</i>	UC/V	AB	AB
24	Ruddy-breasted Crake <i>Zapornia fusca</i>	VR/W	AB	AB
25	Baillon's Crake <i>Zapornia pusilla</i>	VR/W	VR/W/Fo	AB
26	White-breasted Waterhen <i>Amaurornis phoenicurus</i>	C/r/B	C/r/Fo/Ro/B	C/r/Fo/Ro/B
27	Watercock <i>Gallinulex cinerea</i>	VR	AB	AB
28	Purple Swamphen <i>Porphyrio porphyrio</i>	VC/r/B	VC/r/ Fo/Ro/B	VC/r/ Fo/Ro/B
29	Common Moorhen <i>Gallinula chloropus</i>	VC/r/B	VC/r/ Fo/Ro/B	VC/r/ Fo/Ro/B
30	Common Coot <i>Fulica atra</i>	VC/r/B	VC/r/ Fo/Ro/B	VC/r/ Fo/Ro/B
31	Lesser Adjutant <i>Leptoptilos javanicus</i>	UC/V	AB	AB
32	Painted Stork <i>Mycteria leucocephala</i>	C/V/B	C/V/ Ro/Fo/B	C/V/ Ro/Fo/B
33	Asian Openbill <i>Anastomus oscitans</i>	VR/V/B	VR/V/Ro	VR/V/Ro
34	Woolly-necked Stork <i>Ciconia episcopus</i>	NR	VR/V	AB
35	Spot-billed Pelican <i>Pelecanus philippensis</i>	C/V/B	C/V/ Ro/Fo/B	C/V/Ro/F
36	Yellow Bittern <i>Ixobrychus sinensis</i>	R/r	AB	R/V/Ro/Fo
37	Cinnamon Bittern <i>Ixobrychus cinnamomeus</i>	R/r	R/V/Ro/Fo	R/V/Ro/Fo
38	Black-crowned Night Heron <i>Nycticorax nycticorax</i>	VC/r/B	R/V/Ro/Fo	C/V/ Ro/Fo/B
39	Indian Pond Heron <i>Ardeola grayii</i>	C/r	C/r/Ro/Fo	C/r/Ro/Fo
40	Cattle Egret <i>Bubulcus ibis</i>	VC/r	VC/r/Ro/Fo	VC/r/Ro/Fo
41	Grey Heron <i>Ardea cinerea</i>	C/r/B	C/r/Ro/Fo	C/r/Ro/Fo
42	Purple Heron <i>Ardea purpurea</i>	C/V/B	C/V/ Ro/Fo/B	C/V/ Ro/Fo/B
43	Great Egret <i>Ardea alba</i>	C/r	R/V/Fo	R/V/Fo
44	Intermediate Egret <i>Ardea intermedia</i>	C/r	C/r/Ro/Fo	C/r/Ro/Fo
45	Little Egret <i>Egretta garzetta</i>	C/r	C/V/ Ro/Fo/B	C/V/ Ro/Fo/B
46	Black-headed Ibis <i>Threskiornis melanocephalus</i>	C/V/B	C/V/ Ro/Fo/B	C/V/ Ro/Fo/B
47	Eurasian Spoonbill <i>Platalea leucorodia</i>	UC/V/B	VR/V/Ro	VR/V/Ro
48	Indian Black Ibis <i>Pseudibis papillosa</i>	C/V/B	C/V/Fo	C/V/Fo
49	Glossy Ibis <i>Plegadis falcinellus</i>	C/V	C/V/Ro	C/V/Ro
50	Little Cormorant <i>Microcarbo niger</i>	C/r/B	C/r/Ro/Fo/B	C/r/Ro/Fo/B
51	Great Cormorant <i>Phalacrocorax carbo</i>	C/r/B	C/r/Ro/Fo/B	C/r/Ro/Fo/B
52	Indian Cormorant <i>Phalacrocorax fuscicollis</i>	R/V/B	C/r/Ro/Fo/B	C/r/Ro/Fo/B

Appendix 1. Birds at Kukkarahalli Tank recorded during three different time periods (up to 1997: Guruprasad, P. 1997*; 1999-2000 and 2006-2007: current study)

S. No.	Species	Up to 1997	1999-2000	2006-2007
53	Oriental Darter <i>Anhinga melanogaster</i>	C/r/B	C/r/Ro/Fo/B	C/r/Ro/Fo/B
54	Eurasian Thick-knee <i>Burhinus oedicnemus</i>	VC/r/B	VC/r/Ro/Fo/B	AB
55	Black-winged Stilt <i>Himantopus himantopus</i>	C/V	C/V/Fo/Ro	C/V/Fo/Ro
56	Little Ringed Plover <i>Charadrius dubius</i>	R/W	AB	AB
57	Kentish Plover <i>Charadrius alexandrinus</i>	R/W	AB	AB
58	Yellow-wattled Lapwing <i>Vanellus malabaricus</i>	R/W	AB	AB
59	Red-wattled Lapwing <i>Vanellus indicus</i>	C/r/B	VC/r/Fo/Ro	VC/r/Fo/Ro
60	Greater Painted-snipe <i>Rostratula benghalensis</i>	UC	AB	AB
61	Pheasant-tailed Jacana <i>Hydrophasianus chirurgus</i>	C/r/V/B	AB	AB
62	Bronze-winged Jacana <i>Metopidius indicus</i>	C/r/B	C/r/Ro/Fo/B	C/r/Ro/Fo/B
63	Little Stint <i>Calidris minuta</i>	VR/W	AB	AB
64	Pintail Snipe <i>Gallinago stenura</i>	VR/W	AB	AB
65	Common Snipe <i>Gallinago gallinago</i>	VR/W	AB	AB
66	Common Sandpiper <i>Actitis hypoleucos</i>	UC/W	C/W/Fo/Ro	C/W/Fo/Ro
67	Green Sandpiper <i>Tringa ochropus</i>	C/W	C/W/Fo/Ro	AB
68	Common Greenshank <i>Tringa nebularia</i>	UC/W	AB	AB
69	Common Redshank <i>Tringa totanus</i>	R/W	AB	AB
70	Wood Sandpiper <i>Tringa glareola</i>	C/W	UC/W/Fo/Ro	UC/W/Fo/Ro
71	Marsh Sandpiper <i>Tringa stagnatilis</i>	UC/W	UC/W/Fo/Ro	UC/W/Fo/Ro
72	Buttonquail sp. <i>Turnix</i> sp.	UC	AB	AB
73	Brown-headed Gull <i>Chroicocephalus brunnicephalus</i>	VR/W	AB	AB
74	Whiskered Tern <i>Chlidonias hybrida</i>	R/W	AB	AB
75	River Tern <i>Sterna auranita</i>	VR/W	VR/W/Fo	VR/W/Fo
76	Black-bellied Tern <i>Sterna acuticauda</i>	VR/W	AB	AB
77	Black-winged Kite <i>Elanus caeruleus</i>	R/V	AB	AB
78	Oriental Honey Buzzard <i>Pernis ptilorhynchus</i>	NR	NR	VR
79	Egyptian Vulture <i>Neophron percnopterus</i>	C/V	AB	AB
80	Crested Serpent Eagle <i>Spilornis cheela</i>	NR	NR	VR
81	White-rumped Vulture <i>Gyps bengalensis</i>	UC/V	AB	AB
82	Tawny Eagle <i>Aquila rapax</i>	UC/V	AB	AB
83	Western Marsh Harrier <i>Circus aeruginosus</i>	NR	C/V/Fo	C/V/Fo
84	Shikra <i>Accipiter badius</i>	UC/V	C/V/Fo	C/V/Fo
85	Besra <i>Accipiter virgatus</i>	UC/V	AB	AB
86	Brahminy Kite <i>Haliastur indus</i>	C/r/B	C/r/Fo/Ro/B	C/r/Fo/Ro/B
87	Black Kite <i>Milvus migrans</i>	UC/r/B	C/r/Fo/Ro/B	C/r/Fo/Ro/B
88	Common Barn Owl <i>Tyto alba</i>	UC/V	UC/V	AB
89	Spotted Owlet <i>Athene brama</i>	VC/r	VC/r/Fo/Ro/B	VC/r/Fo/Ro/B
90	Collared Scops Owl <i>Otus bakkamoena</i>	VC/r	VR/V/Ro	AB
91	Indian Grey Hornbill <i>Ocyroceros birostris</i>	C/r/B	C/r/Fo/Ro	C/r/Fo/Ro
92	Common Hoopoe <i>Upupa epops</i>	VC/r/B	UC/V/Fo	UC/V/Fo
93	Lesser Golden-backed Woodpecker <i>Dinopium benghalense</i>	C/r	UC/V/Fo	UC/V/Fo
94	White-naped Woodpecker <i>Chrysocolaptes festivus</i>	UC/V	VR/V/Fo	AB
95	Brown-headed Barbet <i>Psilopogon zeylanicus</i>	R/V	AB	AB
96	White-cheeked Barbet <i>Psilopogon viridis</i>	VC/r/B	VC/r/Fo/Ro/B	VC/r/Fo/Ro/B
97	Coppersmith Barbet <i>Psilopogon haemacephalus</i>	VC/r/B	VC/r/Fo/Ro/B	VC/r/Fo/Ro/B
98	Green Bee-eater <i>Merops orientalis</i>	C/r	C/V/Fo	C/V/Fo

Appendix 1. Birds at Kukkarahalli Tank recorded during three different time periods (up to 1997: Guruprasad, P. 1997*; 1999-2000 and 2006-2007: current study)

S. No.	Species	Up to 1997	1999-2000	2006-2007
99	Chestnut-headed Bee-eater <i>Merops leschenaulti</i>	R/V	R/V	AB
100	Blue-tailed Bee-eater <i>Merops philippinus</i>	R/W	UC/W/Fo	AB
101	Indian Roller <i>Coracias benghalensis</i>	C/r/B	UC/V/Fo	UC/V/Fo
102	Common Kingfisher <i>Alcedo atthis</i>	C/r/B	C/r/Fo	C/r/Fo
103	Pied Kingfisher <i>Ceryle rudis</i>	UC/V	UC/V/Fo	UC/V/Fo
104	White-throated Kingfisher <i>Halcyon smyrensis</i>	C	C/r/Fo	C/r/Fo
105	Black-capped Kingfisher <i>Halcyon pileata</i>	VR	AB	AB
106	Rose-ringed Parakeet <i>Psittacula krameri</i>	C/r	C/r/Fo/Ro/B	C/r/Fo/Ro/B
107	Indian Pitta <i>Pitta brachyura</i>	UC/W	R/V	AB
108	Small Minivet <i>Pericrocotus cinnamomeus</i>	UC/V	UC/V/Fo	R/V/Fo
109	Large Cuckooshrike <i>Coracina javensis</i>	R/V	AB	AB
110	Black-headed Cuckooshrike <i>Lalage melanoptera</i>	R/V	R/V/Fo	AB
111	Eurasian Golden Oriole <i>Oriolus oriolus</i>	UC/V	UC/V/Fo	UC/V/Fo
112	Ashy Woodswallow <i>Artamus fuscus</i>	R/V	AB	AB
114	Common Woodshrike <i>Tephrodornis pondicerianus</i>	R/V	AB	AB
115	Common Iora <i>Aegithina tiphia</i>	UC/V	UC/V/Fo	AB
116	Black Drongo <i>Dicrurus macrocercus</i>	C/r	C/r/Fo/Ro	C/r/Fo/Ro
117	Ashy Drongo <i>Dicrurus leucophaeus</i>	UC/V	UC/V/Fo/Ro	UC/V/Fo/Ro
118	White-bellied Drongo <i>Dicrurus caerulescens</i>	VR/V	VR/V/Fo	AB
119	White-throated Fantail <i>Rhipidura albicollis</i>	R/V	R/V/ Fo/Ro	R/V/ Fo/Ro
120	Brown Shrike <i>Lanius cristatus</i>	UC/V	AB	AB
121	Bay-backed Shrike <i>Lanius vittatus</i>	UC/V	UC/V/Fo/Ro	AB
122	Long-tailed Shrike <i>Lanius schach</i>	UC/V	AB	AB
123	Great Grey Shrike <i>Lanius excubitor</i>	UC/V	AB	AB
124	House Crow <i>Corvus splendens</i>	UC/V	VC/r/Fo/Ro	VC/r/Fo/Ro
125	Large-billed Crow <i>Corvus macrorhynchos</i>	VC/r/B	VC/r/Fo/Ro	VC/r/Fo/Ro
126	Indian Paradise-flycatcher <i>Terpsiphone paradisi</i>	UC/V	UC/V/Fo/Ro/B	UC/V/Fo/Ro/B
127	Thick-billed Flowerpecker <i>Dicaeum agile</i>	C/V	C/V/Fo/Ro	C/V/Fo/Ro
128	Pale-billed Flowerpecker <i>Dicaeum erythrorhynchos</i>	C/V	C/V/Fo/Ro	C/V/Fo/Ro
129	Purple-rumped Sunbird <i>Leptocoma zeylonica</i>	C/r/B	C/r/Fo/Ro/B	C/r/Fo/Ro/B
130	Purple Sunbird <i>Cinnyris asiaticus</i>	C/r/B	C/V/Fo/Ro	C/V/Fo/Ro
131	Blue-winged Leafbird <i>Chloropsis cochinchinensis</i>	R/V	AB	AB
132	Streaked Weaver <i>Ploceus manyar</i>	C/r/B	AB	AB
133	Baya Weaver <i>Ploceus philippinus</i>	UC/r/B	UC/V/Fo	UC/V/Fo
134	Red Munia <i>Amandava amandava</i>	R/V	AB	AB
135	Indian Silverbill <i>Euodice malabarica</i>	UC/V	AB	AB
136	White-rumped Munia <i>Lonchura striata</i>	UC/V	AB	AB
137	Scaly-breasted Munia <i>Lonchura punctulata</i>	C/V/B	C/V/Fo/Ro/B	C/V/Fo/Ro/B
138	Black-headed Munia <i>Lonchura malacca</i>	C/r/B	UC/V/Fo	UC/V/Fo
139	House Sparrow <i>Passer domesticus</i>	C/r/B	C/r/Fo/Ro/B	C/r/Fo/Ro
140	Forest Wagtail <i>Dendronanthus indicus</i>	R/W	AB	AB
141	Olive-backed Pipit <i>Anthus hodgsoni</i>	UC/V	AB	AB
142	Paddyfield Pipit <i>Anthus rufulus</i>	C/V	C/V/Fo	C/V/Fo
143	Tawny Pipit <i>Anthus campestris</i>	C/W	AB	AB
144	Western Yellow Wagtail <i>Motacilla flava</i>	R/W	R/V/Fo	R/V/Fo
145	Grey Wagtail <i>Motacilla cinerea</i>	C/W	R/V/Fo	R/V/Fo
146	Citrine Wagtail <i>Motacilla citreola</i>	C/W	AB	AB
147	White-browed Wagtail <i>Motacilla maderaspatensis</i>	C/r/W	C/r/Fo/Ro	C/r/Fo/Ro

Appendix 1. Birds at Kukkarahalli Tank recorded during three different time periods (up to 1997: Guruprasad, P. 1997*; 1999-2000 and 2006-2007: current study)

S. No.	Species	Up to 1997	1999-2000	2006-2007
148	White Wagtail <i>Motacilla alba</i>	UC/W	UC/W/Fo	AB
149	Cinereous Tit <i>Parus cinereus</i>	C/V	C/V/Fo/Ro	C/V/Fo/Ro
150	Rufous-tailed Lark <i>Ammomanes phoenicura</i>	C/V	C/V/Fo/Ro	C/V/Fo/Ro
151	Ashy-crowned Sparrow Lark <i>Eremopterix griseus</i>	C/V	C/V/Fo/Ro	C/V/Fo/Ro
152	Bushlark sp. <i>Mirafra</i> sp.	R/V	AB	AB
153	Oriental Skylark <i>Alauda gulgula</i>	R/V	AB	AB
154	Crested Lark sp. <i>Galerida</i> sp.	UC/V	AB	AB
155	Zitting Cisticola <i>Cisticola juncidis</i>	R/V	AB	AB
156	Ashy Prinia <i>Prinia socialis</i>	C/r/B	C/r/Fo/Ro/B	C/r/Fo/Ro/B
157	Plain Prinia <i>Prinia inornata</i>	C/V	UC/V/Fo/Ro	UC/V/Fo/Ro
158	Common Tailorbird <i>Orthotomus sutorius</i>	C/r/B	C/r/Fo/Ro/B	C/r/Fo/Ro/B
159	Booted Warbler <i>Iduna caligata</i>	C/V	UC/V/Fo/Ro	UC/V/Fo/Ro
160	Blyth's Reed Warbler <i>Acrocephalus dumetorum</i>	UC/V	UC/V/Fo/Ro	AB
161	Clamorous Reed Warbler <i>Acrocephalus stentoreus</i>	UC/V	UC/V/Fo/Ro	UC/V/Fo/Ro
162	Red-rumped Swallow <i>Cecropis daurica</i>	UC/V	UC/V/Fo	UC/V/Fo
163	Wire-tailed Swallow <i>Hirundo smithii</i>	R/V	R/V/Fo	AB
164	Barn Swallow <i>Hirundo rustica</i>	UC/V	C/V/Fo	C/V/Fo
165	Red-whiskered Bulbul <i>Pycnonotus jocosus</i>	UC/r	UC/r/Fo	UC/r/Fo
166	Red-vented Bulbul <i>Pycnonotus cafer</i>	C/r/B	C/r/Fo/Ro/B	C/r/Fo/Ro/B
167	Common Chiffchaff <i>Phylloscopus collybita</i>	C/W	AB	AB
168	Greenish Leaf Warbler <i>Seicercus trochiloides</i>	UC/V	UC/V/Fo/Ro	AB
169	Oriental White-eye <i>Zosterops palpebrosus</i>	R/V	AB	AB
170	Yellow-billed Babbler <i>Turdoides affinis</i>	UC/V	UC/V/Fo/Ro	UC/V/Fo/Ro
171	Rosy Starling <i>Pastor roseus</i>	R/V	R/V/Ro	R/V/Ro
172	Brahminy Starling <i>Sturnia pagodarum</i>	UC/V	UC/V/Ro	UC/V/Ro
173	Chestnut-tailed Starling <i>Sturnia malabarica</i>	UC/V	UC/V/Ro	UC/V/Ro
174	Common Myna <i>Acridotheres tristis</i>	C/r	C/r/Fo/Ro/B	C/r/Fo/Ro/B
175	Jungle Myna <i>Acridotheres fuscus</i>	C/r	C/r/Fo/Ro/B	C/r/Fo/Ro/B
176	Indian Robin <i>Saxicolaoides fulicatus</i>	C/r/B	C/r/Fo/Ro	C/r/Fo/Ro
177	Oriental Magpie Robin <i>Copsychus saularis</i>	C/r/B	C/r/Fo/Ro/B	C/r/Fo/Ro/B
178	Asian Brown Flycatcher <i>Muscicapa dauurica</i>	VR/V	AB	AB
179	Tickell's Blue Flycatcher <i>Cyornis tickelliae</i>	R/V	R/V/ Fo/Ro	R/V/ Fo/Ro
180	Red-breasted Flycatcher <i>Ficedula parva</i>	VR/V	AB	AB
181	Pied Bushchat <i>Saxicola caprata</i>	C/r/B	C/r/Fo/Ro	C/r/Fo/Ro
Total		178	120	104

* Not all species mentioned in Guruprasad (1997) could be traced to definite records. In cases where there is a likely confusion with another species, we have limited the listing to the generic level, e.g., Common Quail *Coturnix coturnix* is listed as Quail sp. *Coturnix* sp.

AB: Absent; B: Breed; C: Common > 75% sightings; Fo: Forage; NR: Not recorded; R: Rare < 25% sightings; r: Resident; Ro: Roost; UC: Uncommon < 50% sightings; V: Visitor; VC: Very common found throughout our transects and during the entire study period; VR: Very rare < than five individual sightings; W: winter visitor.

