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Spatial Variations of Waterbird Diversity at Upper Lake, a Ramsar Site in Bhopal, M.P., India

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Abstract
The wetland birds have restricted habitat requirements and are thus the most vulnerable to changes in habitat conditions. The Upper lake of Bhopal is an important habitat for migratory waterbirds as it lies along the Central-Asian flyway in central India. However rapid urbanization has caused tremendous anthropogenic pressure on lake which may cause adverse impacts to lake and its biodiversity. To assess the impact of varying habitat features like depth, vegetation, surrounding landuse and other anthropogenic disturbances within and around the lake upon waterbirds distribution the present study was conducted on the Upper Lake of Bhopal. Total 68 species of waterbirds were recorded collectively from all the 12 sampling sites of Upper lake. The species richness showed notable variation between different sampling stations. On a spatial scale, it was observed as a general trend that the birds preferred sites with ample food and least human disturbance. The sites with similar physical attributes exhibited variation among waterbird population with an obvious outcome visible in the results that the sites with high human interference were less preferable to birds.
Keywords: Waterbirds, wetlands, depth, spatial variation, India.

1. Introduction

Wetlands are one of the most productive ecosystems on this earth that support a rich array of waterbird communities (Weller, 1999; Grimmett and Inskipp, 2007; Joshi, 2012) on account of their high nutritional value as well as productivity (Paracuellos and Telleria, 2004). The wetland birds utilize a variety of habitats and depend upon a mosaic of microhabitats for their survival (Kumar and Gupta, 2013). Selection of wetlands by waterfowl is influenced by a complex of characteristics including water chemistry, aquatic vegetation, physical features and availability of food (Patra *et al*., 2010). Wetlands are dynamic systems, characterized by fluctuating water, nutrient, and vegetation levels (Dar and Dar, 2009). Such fluctuations result into formation of diverse microhabitats or cells within a wetland differing mainly in availability of food resources to various waterbird groups which in turn display several adaptations for exploiting these resources for sustenance in these ephemeral and patchy habitats (Bolduc and Afton, 2008).

Waterbird species have restricted habitat requirements and are thus the most vulnerable to changes in habitat conditions. Wetlands exchange nutrients and energy with their immediate surroundings (Santra *et al*., 2010) and the increased deforestation, use of pesticides and fertilizers etc. has led to loss of such immense biodiversity hotspots (Duker and Borre, 2001). The unabated and unplanned change incurred upon water resources due to anthropogenic pressure is causing a decline in the water quality of various waterbodies. Waterbird species with restricted foraging niches are under threats from pressures such as loss and modification of habitat via changes in macrophytic composition and structure as well as macroinvertebrate availability. Thus on management and conservation fronts, it is important to identify critical habitats for these birds and thereon a sturdy implementation of legislation and policies.

2. Methodology

The Upper lake of Bhopal is an important habitat for migratory waterbirds as it lies along the Central-Asian flyway in central India and is an important feeding and breeding ground for many resident and migratory bird species. Alongwith its twin Lower lake, it has been designated as Bhoj Wetland, a Ramsar Site, in November 2002 and also as an Important Bird Area (IBA), identified by Birdlife International. With its ecosystem stabilized over the last millennium of its existence, the Upper Lake presently represents all the features of a near-natural wetland. Its diverse flora provides sustenance to a large population of avifauna. However rapid urbanization has caused tremendous anthropogenic pressure on lake. Increased practice of chemical intensive agriculture and reduction in vegetation cover in the catchment area has also impacted the health of the lake negatively. This has accelerated the reduction in the volume of the water, increase in sedimentation, eutrophication, contamination of water etc. which may cause adverse impacts to lake and its biodiversity. The Northern and Eastern part of upper lake represent developed urban areas of Bhopal city including different landuse activities such as residential, commercial, recreational, open spaces etc. The areas adjoining the lake towards North-West, West and South mainly comprise of the rural catchment area of lake with prominent agricultural landuse and is relatively less affected in terms of intense developmental activities but in past decade

rapid expansion of residential, institutional, commercial and farm house activities is noticed here.
To assess the impact of varying habitat features like depth, vegetation, surrounding landuse and other anthropogenic disturbances within and around the lake upon waterbirds distribution the present study was conducted on the Upper Lake of Bhopal from June 2010 to June 2012. The Sampling sites were selected to represent the wide-ranging diversity of habitats available in Upper lake. Sampling points were identified carefully keeping in mind the subject of habitat features and avifaunal occurrence and also such limitations as approachability. Total twelve sampling sites were selected throughout the water body on the basis of bird habitat (Table 1). The depth at all the sampling stations was recorded using a graduated rope and other disturbances to birds were recorded for each site on direct observation basis. The vegetation type present at each site viz. submerged, free-floating, emergent macrophytes and trees and shrubbery available in the marginal marshy areas of lake were documented on each field visit. For bird identification, field visit was done usually between 600 hrs to 1700 hrs. Observations were made from a distance without disturbing the birds using binocular (Nikon binocular 10x50 magnification). Important morphological characters like colour of plumage, legs and shape of the bill were noted. Identification of these waterbirds was done using standard taxonomic keys (Ali and Ripley, 1987 and Ali, 2002).

3. Results and Discussion

In the present study, a total number of 68 species of waterbirds were recorded collectively from all the 12 sampling sites of Upper lake. The species richness showed notable variation between different sampling stations. The sites exhibiting high species richness were S-2 with 66 species, S-11 with 59 species, S-12 with 56 species, S-8 with 55 species, 46 species were recorded at both the stations S-3 and S-7 and 44 species were recorded at station S-1. The sites exhibiting low species richness were S-4 with 13 species, S-5 with 17 species, S-9 with 18 species, S-10 with 21 species and 28 species were recorded at station S-6 (Table 2 and Fig 1).

Among all the waterbird species, diving waterbirds of families Phalacrocoracidae (cormorants, shag, darter) and Anatidae (ducks) were present at all sites of Upper lake indicating the wide foraging range of these waterbird groups. Families Ardeidae (egrets and herons), Laridae (gulls and terns) and Alcedinidae (kingfishers) were present at all sites except deep water site S-9 which is located in the central region of lake near urban periphery. Family Rallidae (waterhens, moorhens, coots) was present at all sites except site S-4 which is a deep water site with excessive anthropogenic disturbance. The presence of the species like waterhens and moorhens of this family in the peripheral parts of all sites may be explained by the thick mat of macrophytic growth in and around the water but at deeper sites the presence of this family was due to a single species i.e. Coots. The absence of this family at site S-4 may be explained by the fact that it is a deep water site with steep slope and negligible macrophytic growth in or around the water hence its suitability to waterhen, moorhen etc. is minimum and due to excessive human interference, coots were also not found to prefer this site. Similarly family Podicipitidae (grebes) was present at all sites irrespective of their depth except sites S-4, S-5 and S-6 which were also highly prone to human disturbance as these sites are located in urban catchment. Family Gruidae was comprised of a single species, the Sarus Crane which is a vulnerable species. The presence of this family was recorded at only two sites, S-8 and S-12 which are both sites with large expanse of marginal shallow water marshy areas and agricultural fields, shrubbery and scattered trees in the immediate surroundings that may have provided suitable protection to these birds. The families Jacanidae (jacanas), Chardriidae (sandpipers, redshanks, greenshanks, lapwings, plovers)and Recurvirostridae (stilts), that are formed of small wader species were present throughout the lake except at very deep water sites. Large wading birds of families Ciconiidae (storks), Threskiornithidae (ibis, spoonbill) and snipes of family Rostratulidae were present only at sites with shallow margins and were absent from deep water sites S-4, S-5, S-6, S-9 and S-10.

In the entire study, it was observed that the species richness was high for shallower sites which may be due to easy and abundant availability of food in such habitat (Suter, 1994; Stanevicius, 1999) whereas lower species richness was recorded at deeper sites. A wetland may have one or more habitats created due to water depth gradient formed as an outcome of fluctuations in the water regime **(**Desgranges et al., 2006). Waterbirds take advantage of water level fluctuations on account of various morphological adaptations that help to exploit food resources at specific water depths (Bolduc, 2002). The availability of assorted waterbird diet (Davis & Smith 1998; Sanders 2000) and furthermore the accessibility of this food is likewise important to waterbirds which is indeed controlled by water depth (Velasquez 1992; Nagarajan & Thiyagesan 1996; Elphick & Oring 1998; Isola *et al* . 2000). Such variation in depth may have resulted into higher diversity of waterbirds at shallow sites where presence of waders as well as ducks was observed while at deeper stations the absence of small waders as well as storks, ibises and other shoreline birds resulted in restricted waterbird diversity with abundance of ducks in these sites.

Upper lake provides varied habitats for a diverse range of resident and migratory wetland birds with marshy plant growth, deep open water zone, productive littoral area, terrestrial platforms, earth mounds with scattered trees, bushy vegetation and surrounding fertile agricultural fields. A greater richness of waterbirds was

observed at sites S-2, S-3, S-8, S-11 and S-12 which are the sites with profuse macrophytic growth. In addition, the presence of stray trees and scattered vegetation cover in the shoreline might have extended comfortable shelter and suitable foraging grounds for the wetland birds. Water birds require a cluster of platforms within the water bodies in order to sit there for basking during the winters which are also available at these sites of upper lake (Kumar and Gupta, 2009). The availability of profuse green belt in and around these sites may have facilitated easy means of roosting and perching to waterbirds which may account for the higher diversity of avifauna observed at these sites. Chandana *et al*., (2008) reported similar observations that aquatic birds were abundant at sites with abundant aquatic vegetation in their study at Embillakala lagoon. According to them, the sites that maintained moderate water depth with more aquatic macrophytes and more associated grasslands are preferred by birds. According to Snyder, (2002) waterbird diversity is much related to vegetation profile of habitat and sites offering less complex habitats have low diversity. Plant diversity provides a space to birds for nesting, feeding and breeding. Vegetative habitat (macrophytes) has been reported by several workers as an important biotic factor controlling the selection of wetlands by waterfowl (Lillie and Evrard, 1994; Hoyer and Canfield, 1994; Patra *et al*., 2010). The sites of Upper Lake exhibiting high waterbird richness are surrounded by agricultural land and in some places with adjacent forestlands and are too shallow towards periphery resulting in production of muddy marshes towards the margin. The high species richness of waterbirds at sites S-8, S-11 and S-12 may be due to presence of dense macrophytic growth owing to the large area of shallow water with gentle slope at these sites and much agriculture practice prevalent in the immediate catchment providing large area of nutrient rich soil substrate supporting lush macrophytic growth in this zone. The submerged and free floating macrophytes were present at all the sampling sites of upper lake. The site S-3, which is an island, a holy place for pilgrims, is surrounded by profuse aquatic floating, submerged weeds and thus supported fair number of waterbird species in early hours when the disturbing tourist activities were negligible. The site S-2 is one of the most important areas for bird conservation in the region and has long been understood to be extremely important for waterbirds especially gregarious large waterbirds, particularly cranes, storks, ibises and cormorants for the reason that it provides two key habitat types; swampy forest and shallow inundated zones that are essential to waterbirds. Tall-emergent vegetation, open shore, lawn, and canopy are considered to be the primary habitat elements determining waterbird distribution (Traut and Hostetler, 2004; Campbell *et al*., 2006).

The various disturbance factors levied upon birds by human interference affects the habitat choice of birds. In Upper Lake, there was lower species richness observed in urban areas with high anthropogenic disturbance to waterbirds as compared to sites with similar habitat features in rural areas with less disturbance. Birds react quickly to changes in their habitat owing to their high mobility. Thus birds are known to be useful biological indicators of health of an ecosystem as they respond to secondary changes resulting from primary causes (Rathore and Padate, 2008). The rapid urban development in present era and resultant anthropogenic pressure has affected the wetland habitat immensely and such changes in turn affect the population and diversity of water birds (Mohan and Gaur, 2008). All wetlands differ in the habitat types available to wetland avifauna and many wetlands have been altered functionally through human intervention (White, 2003). In the present study, intense direct or indirect human interference has been observed in one or other form, at sites S-1, S-3, S-4, S-5, S-6 and S-7 of Upper Lake. These sites are being used for activities that disturb and deteriorate waterbird habitat of the area through washing, bathing, water collection for house hold work, waste dumping, sewage inlets, religious activities, livestock grazing and recreational pursuits such as swimming, boating, and fishing etc. and this human pressure is showing visible negative effect on the waterbird diversity at these sites, which is considerably low as compared to their less disturbed counterparts. Fletcher *et al*., (2005) found in their study that avian species richness changed dramatically as a function of recreational activity. Disturbance is particularly damaging, because it affects access to and acquisition of requirements throughout the annual cycle of waterbirds. Urban habitats are also characterized by high levels of human-associated disturbance, such as traffic, construction, and recreation (Jokimaki, 1999) leading to changes in structure and function of habitat, such as water column depth, wetland substrate, shoreline, and vegetation strata, which may cause long term impact on waterbird composition. According to Adamus *et al*., (2001) frequent visitation of wetlands by boaters and other recreationists can adversely affect waterbirds (Dahlgren & Korschgen, 1992; Erwin *et al*., 1993; Klein *et al*., 1995; Rogers & Smith, 1997) as human intrusion can disrupt bird feeding patterns and cause at least temporary shifts in bird community richness and abundance (Riffell *et al*., 1996).

In Upper lake, important waterbird species on account of their conservation status were observed. The sites S-2, S-8, S-11 and S-12 with shallow margins with dense vegetation progressing towards open littoral zone were most important for large waders like crane, storks and ibises while divers and aerial foragers equally preferred deep zone of Upper Lake as well. Ferruginous Pochard prefers fresh standing water and presence of dense submerged, floating, emergent and shoreline vegetation which were available at deep water site S-9 and the comparatively shallower water of site S-2 which is a protected zone of Upper Lake. The rich growth of aquatic plants (*Potamogeton* spp., *Ceratophyllum* spp., *Scirpus* spp. etc.) at these sites may have provided suitable habitat. Black necked Stork was recorded at marshy edges of sites S-2 and S-11 of Upper Lake. It

forages in shallow water and takes fish, amphibians, molluscs, insects and other arthropods. Oriental White Ibis was also found at the sites S-1, S-2, S-8, S-11 and S-12 which have shallow margins with dense vegetated canopy. White necked Stork showed a preference for habitats with shallow water margin although occassionally it also used artificial habitats such as surrounding cultivated fields of sites S-11 and S-12. River Tern which is an endangered species was present at nearly all sites of Upper Lake including polluted urban sites S-5 and S-6 where excessive effluent discharge has considerably jeopardised the water quality leading to high productivity indicating the presence of abundant suitable food for this species at these sites.

4. Conclusion

The suitability of Upper lake to waterbirds is mainly due to availability of good habitat for waterbirds, both residents as well as migratory. A vast segment of waterbird diversity is sustained in the shallow and intermediate depth expanse of the lake. Along with the presence of marginal dense canopy cover (sites S-1, S-2, S-7, S-8, S-11 and S-12), agricultural fields (S-8, S-11 and S-12), ample marshy segments and open mudflats along the periphery (S-2, S-8 and S-12), protected site status (S-2) and availability and accessibility of all kinds of preferred food resources, the lake caters to all the life cycle requirements of waterbirds creating a bird haven in the area. The presence of all kind of submerged and free floating macrophytes (*Ceratophyllum, Potamogeton, Hydrilla, Eichhornia, Pistia, Nymphaea* etc.) in the lake provide the birds with plentiful food material and also the emergent vegetation (*Cyperus, Ipomoea, Typha, Cyperus* etc.) in the shoreline areas offer proper screen to the birds from human interference and safety from predators. Divergent waterbirds like cormorants, egrets and herons, storks and ibises, crane, ducks, jacanas, lapwings, stilts, sandpipers, gulls and terns, kingfishers etc. find refuge in this lake emphasizing the overall importance of this waterbody.

The population of birds showed a definite trend of variation along different sites. On a spatial scale, it was observed as a general trend that the birds preferred sites with ample food and least human disturbance. The sites with similar physical attributes exhibited variation among waterbird population with an obvious outcome visible in the results that the sites with high human interference were less preferable to birds. The shallow water habitat of sites S-7 and S-12 offered similar feature to waterbirds in terms of habitat configuration but the preference of birds was dramatically elevated for S-12. This was because the site S-7 was facing much human interference in terms of agriculture, fishing, bathing, waste dumping etc. making it less preferred by the birds. Among the sites S-1, S-2, S-3, S-5, S-6, S-8, S-11, the sites S-1 and S-3, although in the adjacent locale to site S-1, were less preferred by birds owing to the tourist activities incident at these sites while S-1, which is a protected area of Van Vihar National Park showed high waterbird diversity due to least disturbance experienced by birds here. The sites S-5 and S-6 were facing anthropogenic pressure in form of high traffic and pollution from unrestricted effluent discharge from the surrounding urban catchment and thus very low number of waterbirds used these sites. Among the sites S-8 and S-11 which were both having a predominantly agricultural landuse in the immediate catchment showed considerable difference in the population of waterbirds as the site S-11 was near a village with a narrower stretch of space available to the birds in the surroundings of waterbody whereas the site S-8 was near the forested belt of lake leading into villages. This forested scape when filled with rainwater, provided an excellent habitat to the waterbirds mainly due to the easy prey accessibility in the seasonally created marshy wetland area and also by providing a shelter to birds and forming a buffer between the human habitation and bird occupied region thus yet again demonstrating the negative impact of human disturbance to birds. The deep water sites S-4, S-9 and S-10 confirmed this observation where the site S-4 lies along the urban margin of Upper Lake with lots of pressure in form of religious and recreational activities, boating, washing, bathing etc. supported least waterbird population in the entire study. Among the other deep water sites, S-9 and S-10 were located in the central zone of the lake. Site S-9 was located towards the urban periphery and some amount of human disturbance in form of boats and fishing was observed here and thus it supported significantly less waterbirds when compared to S-10 which lies in rural catchment and faced least disturbance. Thus, through all these observations it can be concluded that water depth, vegetation structure and human disturbance has significant effect on waterbird population and habitat choices.

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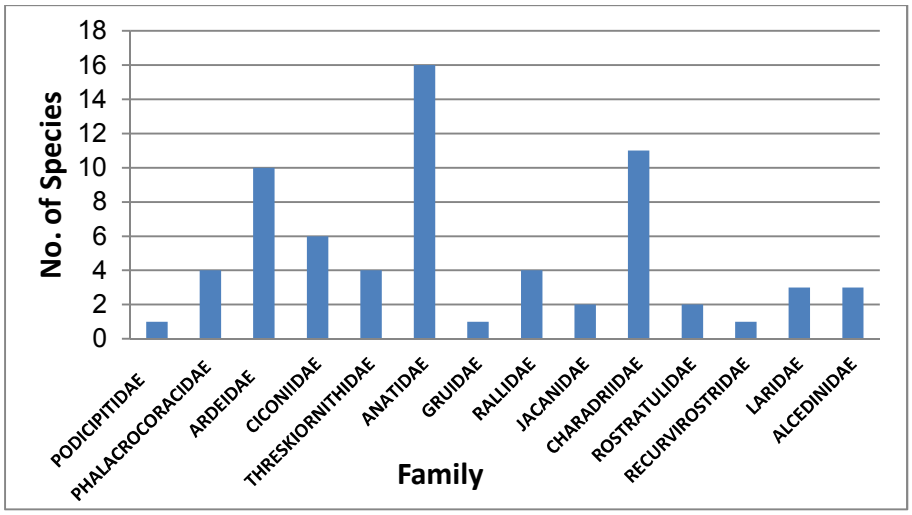

Figure 1: Spatial variation in species richness of waterbirds in Upper Lake (2010-12)

Table 1: Description of sampling sites studied at Upper lake –

Site	Location	Depth	*Vegetation	Remarks
S-1	$23^0$13'02.71"N $77^0$22'28.62" E	2-4 m	S>F>E	Tourism, Religious activities
S-2	$23^0$14'28.77" N $77^0$21'50.86" E	2-4 m	S>F>E	Tourism
S-3	23°14'43" N 77°22'33.1" E	2-4 m	S>F>E	Tourism, Religious activities
S-4	23°15'05" N 77°23'43.08" E	4-6 m	S>F	Religious activities, **Others
S-5	23°15'17.7" N 77°23'47.8" E	2-4 m	S>F	Pollution, Traffic
S-6	23°15'38.7" N 77°22'47.1" E	2-4 m	S>F>>E	Pollution, Traffic
S-7	23°15'21.12" N 77°22'4.39" E	0-2 m	S>E>F	Agriculture, **Others
S-8	$23^0$15'35.09" N $77^0$20'16.50" E	2-4 m	S>E>F	Agriculture, **Others
S-9	23°15'03.90" N 77°22'26.20" E	4-6 m	S>F	NIL
S-10	$23^0$14'44.5" N $77^0$20'39.5" E	4-6 m	S>F	NIL
S-11	23°14'39.5" N 77°20'37.86" E	2-4 m	S>F>E	Agriculture, **Others
S-12	$23^0$14'24.66" N $77^0$20'54.57" E	0-2 m	S>E>F	Agriculture, **Others

* S = Submerged; F = Free-floating; E = Emergent
**Others = Washing, bathing, fishing, cattle grazing etc.
#Source = Personal Observations

Table 2: Waterbird distribution at various sampling sites of Upper lake –

S.No.	Scientific Name	Common Name	Sampling Site											
			S-1	S-2	S-3	S-4	S-5	S-6	S-7	S-8	S-9	S-10	S-11	S-12
1. Order - Podicipediformes; 1(a). Family - Podicipitidae														
1	*Tachybaptus ruficollis*	Little Grebe	+	+	+	-	-	-	+	+	+	+	+	+
2. Order - Pelecaniformes; 2(a). Family - Phalacrocoracidae														
2	*Phalacrocorax carbo*	Great Cormorant	+	+	+	-	-	-	+	+	-	-	+	+
3	*Phalacrocorax fuscicollis*	Indian Shag	+	+	+	-	-	-	+	+	-	-	+	+
4	*Phalacrocorax niger*	Little Cormorant	+	+	+	+	+	+	+	+	+	+	+	+
5	*Anhinga melanogaster*	Darter	+	-	-	-	-	-	+	+	-	-	+	+
3. Order - Ciconiiformes; 3(a). Family - Ardeidae														
6	*Casmerodius albus*	Large Egret	+	+	+	-	-	-	+	+	-	-	+	+
7	*Egretta garzetta*	Little Egret	+	+	+	+	+	+	+	+	-	+	+	+
8	*Mesophoyx intermedia*	Median Egret	+	+	+	-	-	+	+	+	-	-	+	+
9	*Bubulcus ibis*	Cattle Egret	+	+	+	+	+	+	+	+	-	-	+	+
10	*Ardea cinerea*	Grey Heron	+	+	+	-	-	+	+	+	-	-	+	+
11	*Ardea purpurea*	Purple Heron	-	+	-	-	-	-	-	+	-	-	+	+
12	*Butorides striatus*	Little Green Heron	-	+	-	-	-	-	-	-	-	-	-	+
13	*Nycticorax nycticorax*	Black-crowned Night-Heron	+	+	+	+	+	+	+	+	-	-	+	+
14	*Ardeola grayii*	Indian Pond-Heron	+	+	+	+	+	+	+	+	-	-	+	+
15	*Ixobrychus cinnamomeus*	Chestnut Bittern	-	+	-	-	-	-	-	-	-	-	-	+
3(b). Family - Ciconiidae														
16	*Mycteria leucocephala*	Painted Stork	+	+	+	-	-	-	+	+	-	-	+	+
17	*Anastomus oscitans*	Asian Openbill-Stork	+	+	+	-	-	-	+	+	-	-	+	+
18	*Ciconia episcopus*	White-Necked Stork	+	+	-	-	-	-	+	+	-	-	+	+
19	*Ciconia ciconia*	European White Stork	-	+	-	-	-	-	-	+	-	-	+	+
20	*Ciconia nigra*	Black Stork	-	+	-	-	-	-	+	-	-	-	+	+
21	*Ephippiorhynchus asiaticus*	Black-Necked Stork	-	+	-	-	-	-	-	-	-	-	+	-
3(c). Family - Threskiornithidae														
22	*Threskiornis melanocephalus*	Oriental White Ibis	+	+	-	-	-	-	-	+	-	-	+	+
23	*Pseudibis papillosa*	Black Ibis	-	+	-	-	-	-	-	+	-	-	+	-
24	*Plegadis falcinellus*	Glossy Ibis	+	+	+	-	-	-	+	+	-	-	+	+
25	*Platalea leucorodia*	Eurasian Spoonbill	+	+	+	-	-	-	+	+	-	-	+	-

4. Order - Anseriformes; 4(a). Family - Anatidae														
26	*Anser indicus*	Bar-headed Goose	-	+	-	-	-	-	-	-	-	-	-	-
27	*Tadorna ferruginea*	Brahminy Shelduck	+	+	+	-	-	-	-	+	+	+	+	+
28	*Sarkidiornis melanotos*	Comb Duck	+	+	+	-	+	+	+	+	+	+	+	+
29	*Dendrocygna javanica*	Lesser Whistling-Duck	+	+	+	+	-	+	+	+	+	+	+	+
30	*Anas acuta*	Northern Pintail	-	+	-	-	-	-	+	+	+	+	+	+
31	*Anas crecca*	Common Teal	-	+	-	-	-	-	-	-	+	+	+	+
32	*Anas poecilorhyncha*	Spot-billed Duck	+	+	+	-	-	+	+	+	+	+	+	+
33	*Anas platyrhynchos*	Mallard	+	+	+	-	-	-	+	+	+	+	+	+
34	*Anas strepera*	Gadwall	-	+	+	-	-	-	+	+	+	+	+	+
35	*Anas penelope*	Eurasian Wigeon	+	+	+	+	-	-	+	+	+	+	+	+
36	*Anas clypeata*	Northern Shoveller	-	+	+	-	-	-	+	+	+	+	+	+
37	*Anas querquedula*	Garganey	-	+	+	-	-	+	+	+	+	+	+	+
38	*Rhodonessa rufina*	Red-crested Pochard	+	+	+	+	-	+	-	-	+	+	-	-
39	*Aythya ferina*	Common Pochard	-	+	+	+	-	+	-	-	+	+	+	-
40	*Aythya nyroca*	Ferruginous Pochard	-	+	-	-	-	-	-	-	+	-	-	-
41	*Nettapus coromandelianus*	Cotton Teal	+	+	+	-	-	-	+	+	+	+	-	-
5. Order - Gruiformes; 5(a). Family - Gruidae														
42	*Grus antigone*	Sarus Crane	-	-	-	-	-	-	-	+	-	-	-	+
5(b). Family - Rallidae														
43	*Amaurornis phoenicurus*	White-breasted Waterhen	+	+	+	-	+	+	+	+	-	-	+	+
44	*Gallinula chloropus*	Common Moorhen	+	+	+	-	+	+	+	+	-	-	+	+
45	*Porphyrio porphyrio*	Purple Moorhen	+	+	+	-	-	-	+	+	-	-	+	+
46	*Fulica atra*	Common Coot	+	+	+	-	-	+	-	+	+	+	+	+
6. Order - Charadriiformes; 6(a). Family - Jacanidae														
47	*Metopidius indicus*	Bronze-winged Jacana	+	+	+	+	+	+	+	+	-	-	+	+
48	*Hydrophasianus chirurgus*	Pheasant-tailed Jacana	+	+	+	-	-	+	+	+	-	-	+	+
6(b). Family - Charadriidae														
49	*Vanellus indicus*	Red-wattled Lapwing	+	+	+	+	+	+	+	+	-	-	+	+
50	*Charadrius dubius*	Little Ringed Plover	-	+	-	-	-	-	+	+	-	-	+	+
51	*Charadrius alexandrinus*	Kentish Plover	-	+	+	-	-	-	-	+	-	-	+	+
52	*Tringa totanus*	Common Redshank	+	+	+	-	-	+	+	+	-	-	+	+
53	*Tringa nebularia*	Common Greenshank	-	+	-	-	+	+	+	+	-	-	+	+
54	*Actitis hypoleucos*	Common Sandpiper	+	+	+	-	+	+	+	+	-	-	+	+
55	*Tringa stagnatilis*	Marsh Sandpiper	+	+	+	-	-	+	-	+	-	-	-	-
56	*Tringa glareola*	Wood Sandpiper	-	+	-	-	-	-	+	-	-	-	+	-
57	*Calidris temminckii*	Temminck's Stint	-	+	-	-	-	-	-	-	-	-	-	+
58	*Numenius arquata*	Eurasian Curlew	-	+	-	-	-	-	-	-	-	-	+	-
59	*Limosa limosa*	Black-tailed Godwit	-	+	+	-	-	-	-	-	-	-	+	-
6(c). Family - Rostratulidae														
60	*Rostratula benghalensis*	Greater Painted-Snipe	-	+	-	-	-	-	+	+	-	-	+	+
61	*Gallinago gallinago*	Common Snipe	+	+	+	-	-	-	+	+	-	-	+	+
6(d). Family - Recurvirostridae														
62	*Himantopus himantopus*	Black-winged Stilt	+	+	+	-	+	+	+	+	-	-	+	+
6(e). Family - Laridae														
63	*Sterna aurantia*	River Tern	+	+	+	-	+	+	+	+	-	+	+	+
64	*Sterna acuticauda*	Black-bellied Tern	+	+	-	-	-	-	-	+	-	-	+	+
65	*Larus brunnicephalus*	Brown-headed Gull	+	+	+	+	-	-	-	+	-	-	+	+
7. Order - Coraciiformes; 7(a). Family - Alcedinidae														
66	*Ceryle rudis*	Lesser Pied Kingfisher	+	+	+	-	+	+	+	+	-	+	+	+
67	*Alcedo atthis*	Small Blue Kingfisher	+	+	+	+	+	+	+	+	-	+	+	+
68	*Halcyon smyrnensis*	White breasted Kingfisher	+	+	+	-	+	+	+	+	-	-	+	+
Total no. of species at each site			**44**	**66**	**46**	**13**	**17**	**28**	**46**	**55**	**18**	**21**	**59**	**56**

(+) = Present; (-) = Absent

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