

**UNESCO-IUCN Enhancing Our Heritage Project:
Monitoring and Managing for Success in Natural World Heritage Sites**

Technical Report No. 10

**Ecological Monitoring
in Keoladeo National Park and
its Environs for Enhancing Management Effectiveness**



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Contents

Background	1
Introduction	1 - 3
Study area	3 - 7
Methodologies	8
Results	9 - 14
Discussion	15 - 17
Future Activities	17
References	18
Appendices	19 - 20

1. Background

Enhancing Our Heritage: Managing and Monitoring for Success in Natural World Heritage Sites is an UNESCO – IUCN project funded by the United Nations Foundation. The four year project is being implemented in ten world heritage sites located in Africa, South Asia and Latin America. The three project sites in South Asia are Keoladeo National Park, Bharatpur, Kaziranga National Park, Assam and the Royal Chitwan National Park, Nepal. The Wildlife Institute of India, Dehradun has been selected as a Regional Partner Institution to provide technical back stopping for project implementation in South Asia. One of the principal objectives of the project is to promote the development of monitoring and evaluation systems and to facilitate adaptive management. Based on the lessons learnt, the project aims to enhance the periodic reporting process for the World Heritage Sites. The main aim of the project is to demonstrate how using assessment, monitoring and reporting framework management effectiveness can be enhanced.

An initial management effectiveness evaluation as per the project methodology was carried out in Keoladeo National Park in the year 2002 – 03. Unfortunately, the year was a drought year and hence a mechanism for Long Term Monitoring for the KNP wetlands and adjoining catchments could not be devised. A programme for ecological monitoring of the park and its environs has been recently designed and is being implemented. The objectives of this monitoring process are:

1. Monitor population trends of raptor community – the top avian predators, as indicator of ecosystem health
2. Monitor composition and population trends in 'heronry'
3. Survey satellite wetlands around KNP for
 - a. Documenting avifaunal diversity
 - b. Evaluating the role of satellite wetlands for migratory and resident birds especially waterfowls

2. Introduction

Raptors, or birds of prey, including the hawks, falcons, eagles, vultures, and owls, occur throughout Indian ecosystems. As predators, most of them kill other animals for their food. Compared to most other animal groups, birds of prey naturally exist at relatively low population

levels and are widely dispersed within their habitats. As top predators, raptors are one of key species for understanding the dynamics of ecosystems. Changes in raptor status can reflect changes in the availability of their prey species, including population declines of mammals, birds, reptiles, amphibians, and insects. Changes in raptor status can also be an indicator of more subtle detrimental environmental changes such as chemical contamination and the occurrence of toxic levels of heavy metals e.g. mercury, lead. Consequently, determining and monitoring the population status of raptors are critical steps in the conservation and management of our natural resources. The recent crash in the vulture population in India has certainly raised alarms in the society (Prakash *et al.* 2003). The KNP stands at fourth position (40 species) in terms of supporting raptors species in India (Samant *et al.* 2003). Others being Kaziranga National Park (45), Corbett National Park (44), Neora Valley National Park (43) and Singhalia National Park (40). Comparatively, KNP is the smallest national park but availability of mosaic of habitats therein seems to be a major factor in attracting a large raptor congregation. The variety of habitats available i.e. wetland, part grassland, and part semi-arid forested grassland gives an idea of the multitude of niches present within KNP. The park supports resident and both staging and wintering raptors during winters every year. Long term monitoring of this group of birds is needed for designing conservation strategies for the KNP ecosystem. Since they are 'umbrella species', holding large territories their conservation indirectly helps in the conservation of many other micro and macro fauna and flora.

The Park has one of the world's most spectacular heronries, which harbour a large number of resident and migratory birds (c 15 species). KNP ranks among top 10 heronries in India and over 5000 pairs or nests have been recorded in the past decade (Subramanya 2003). Colonial waterbirds have often been proposed as a group that could be used as indicators of environmental changes (Kushlan 1993). Several aspects of their biology make these birds likely candidates as indicator species. They are high in the trophic pyramid of aquatic ecosystems and can indicate problems with species lower in the pyramid. Because they nest in groups, large number of specimens may be collected for toxicological work and reliable estimates of the breeding population size are possible. In KNP, the largest heronry is located along Ghana Canal in Block – K with other smaller colonies in Blocks – D, B and L (Fig. 1).

Catchment areas are areas that supply surface water to a common watercourse. The health of a wetland is closely related to the land management practices in its catchment and the quality

of water entering into it. Presently, the Park is mostly dependent for its water requirement on River Gambhir and waters from the catchment areas. The Park is itself not a self sustaining unit owing to its small size (c 29 km²) and hence cannot fulfill all the ecological requirements of birds arriving to it in winter especially migratory waterfowls. Birds therefore move out and take shelter in scattered satellite wetlands all around it. However, there is no baseline data presently available on the population dynamics in the surrounding water bodies. The reason for recent massive decline in the water birds could be attributed to the rapid changes taking place in the wetlands around the Park. To devise an effective management strategy for the conservation of birds especially migratory waterfowls status of wetlands around the Park is needed. These areas become strategic refuge areas in times of drought, often supporting animals and plants that are found nowhere else.

3. Study area

3.1. Keoladeo National Park

Keoladeo National Park (KNP) (27°7'6"N – 27° 12'2"N and 77° 29'5" E – 77° 33'9"E) is a 29 km² area situated on the extreme western edge of the Gangetic basin that was once confluence of Rivers Gambhir and Banganga in Bharatpur district of the state of Rajasthan. Bharatpur is c 180 km from Delhi to its South-East. Its northern border touches district Gurgaon of state Haryana, and eastern border touches District Mathura and Southern Border touches District Agra of state Uttar Pradesh and Dholpur District of Rajasthan, and in the south-west Dousa district and in the North-West Alwar District of Rajasthan is situated.

KNP has a unique mosaic of habitats that include wetlands, woodlands, scrub forests, grasslands that supports an amazing diversity of both plant and animal species. Keoladeo National Park's flora consists of 375 species of angiosperms of which 90 species are wetland species (Perennou and Ramesh 1987). The fauna includes more than 350 species of birds, 27 species of mammals, 13 species of reptiles, 7 amphibians and 43 fishes (Vijayan 1991). Macro invertebrates too abound in the park. The unique mosaic of habitats includes physiognomic types of forest, woodland, scrub woodland, savanna woodland, tree savanna, low grasslands with scattered trees and

scrub, plantations and wetland. Forests, mostly in the north-east of the park, are dominated by kadam *Mitragyna parvifolia*, jamun *Syzygium cuminii* and babul *Acacia nilotica*. The 'Kadam' is representative of climax community of swamp/ riverbed vegetation.

This diversity of habitats supports the highest congregation of waterfowl in the region and is also home to many resident terrestrial and local migratory species (Fig.1). The wetlands of the park are host to the most spectacular heronry of the region. 15 species of birds nest here forming an extensive heronry from the month of July to September. As the park lies on the Central Asian Flyway of the Asia Pacific Global Migratory Flyway, it is a staging / wintering ground for a huge number of migratory waterfowl that breed in the Palearctic region. KNP has been the only wintering ground for the central population of the endangered Siberian Crane (*Grus leucogeranus*). The park is unique in being bound by a stone - masonry wall and agricultural fields and villages in immediate surroundings, thus, lacking a buffer zone. The park is both a Ramsar Site as well as a World Heritage site. It has a long and unique history as it was once part of erstwhile state of Bharatpur and had been managed as a duck shooting reserve.

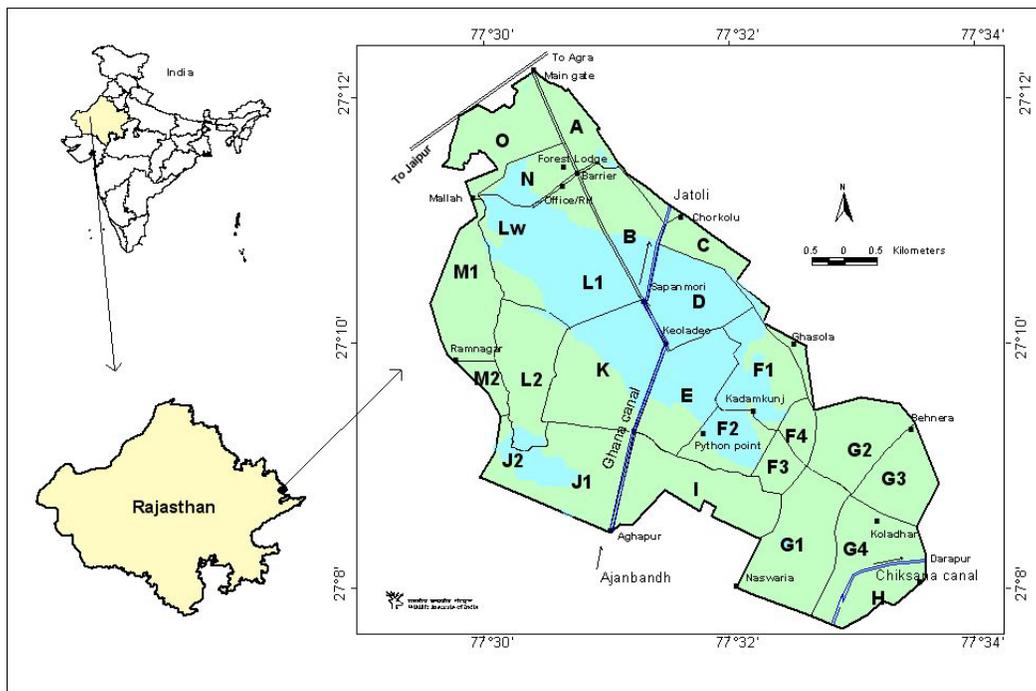


Figure. 1. Location map of Keoladeo National Park. Blocks- B, D, E, F, K, L, and N remain submersible during good rainfall years and provide breeding grounds for heronry birds.

3.2. Catchment areas

Surveys in the catchment areas of the Keoladeo National Park from KNP are being conducted along the course of Rivers Banganga, Gambhiri and Ruparel in a radius of 100 km from the park. These rivers are responsible for meeting the water requirements of the park. Survey sites include both ephemeral and perennial reservoirs situated along these Rivers.

The River Banganga which originates from the low hills of Bairath in Jamwa Ramgarh in Jaipur district, flows towards the east, entering Sawai Madhopur district and finally meets the River Gambhiri near tehsil Bayana of District Bharatpur. The River Gambhir originating from Karauli hills (Pachana Dam) of Karoli district flows through this district to a greater length and inundates several areas of Bharatpur district before joining the river Yamuna in Uttar Pradesh. Rooparel River starts from hills of district Alwar entering into Bharatpur from tehsil Kaman. The rivers Gambhir and Banganga remained two principal sources of water to KNP. However, the River Banganga has long dried up, putting the pressure on the River Gambhir to supply water to Bharatpur (Fig. 2). More recently in 1991, the Panchana Dam (water holding capacity over 2100 million cubic feet) was constructed on the River Gambhir to mitigate flooding and fulfill the irrigation needs of the local agricultural community.

3.2.1 Specific survey locations

1. Ajan bundh (27° 07' 50.8" N, 77° 30' 50.4") (Bharatpur)

It is situated about ½ km to the south of KNP. It acts as a temporary reservoir holding water both from Gambhir and Banganga which is later released to KNP.

2. Terah mori dam (27° 06' 47.7" N, 77° 39' 43.5") (Fatehpur Sikri)

It is situated c 20 km away from Bharatpur in Fatehpur Sikri district of Uttar Pradesh receiving water from Ajan dam and later released to Yamuna River, Agra (UP)

3. Chiksana bundh (27° 11' 02.9" N, 77° 38' 57.2") (Bharatpur)

It is situated c 15 km to the east of Bharatpur.

4. Motijheel (Sevar)

Situated c 5 km of Bharatpur city this drain is meant to pass River Ruparel water to UP.

5. Bhandor (Kumher)

It is situated about 15 km away from Bharatpur. During monsoon till whole of September/October the agricultural fields remain inundated providing feeding grounds to migratory waterfowls.

6. Babula and Bhatawali (Kumher)

These areas receive water from river Banganga acting as temporary wetlands for several months. A large congregation of migratory birds takes refuge here during September/October.

7. Nonera (27° 46' 26.3" N, 77° 17' 44.0") (Kama)

The rain water and water from Gudgaona canal through seepage get stored in Nonera which is situated about 80 km from Bharatpur. Large agricultural fields remain under water till December/January making a perfect refuge for enormous number of migratory birds.

8. Bund Baretha (26° 48' 27.2" N, 77° 25' 33.8") (Bayana)

Around 60 km far of Bharatpur this perennial reservoir attracts lots of resident as well as migratory birds through out the year. This also supplies water to Bharatpur city.

9. Pichuna canal (Rupbas)

This is situated about 25 km from Bharatpur. The Gambhir river water flows through this canal and reaches to Ajan bund.

10. Kalekoh dam (Dosa)

About 100 km from Bharatpur this reservoir receives Banganag river water and also acts as an important winter resort to large number of migratory birds.

11. Nari Semri (27° 39' 34.8" N, 77° 31' 13.8") (Mathura,UP) and Aanjnokh (27° 43' 13.7" N, 77° 29' 14.0") (Chatta, UP)

Due to low depression rain water gets accumulated for several months providing shelter to large number of migratory water birds especially Greater Flamingos.

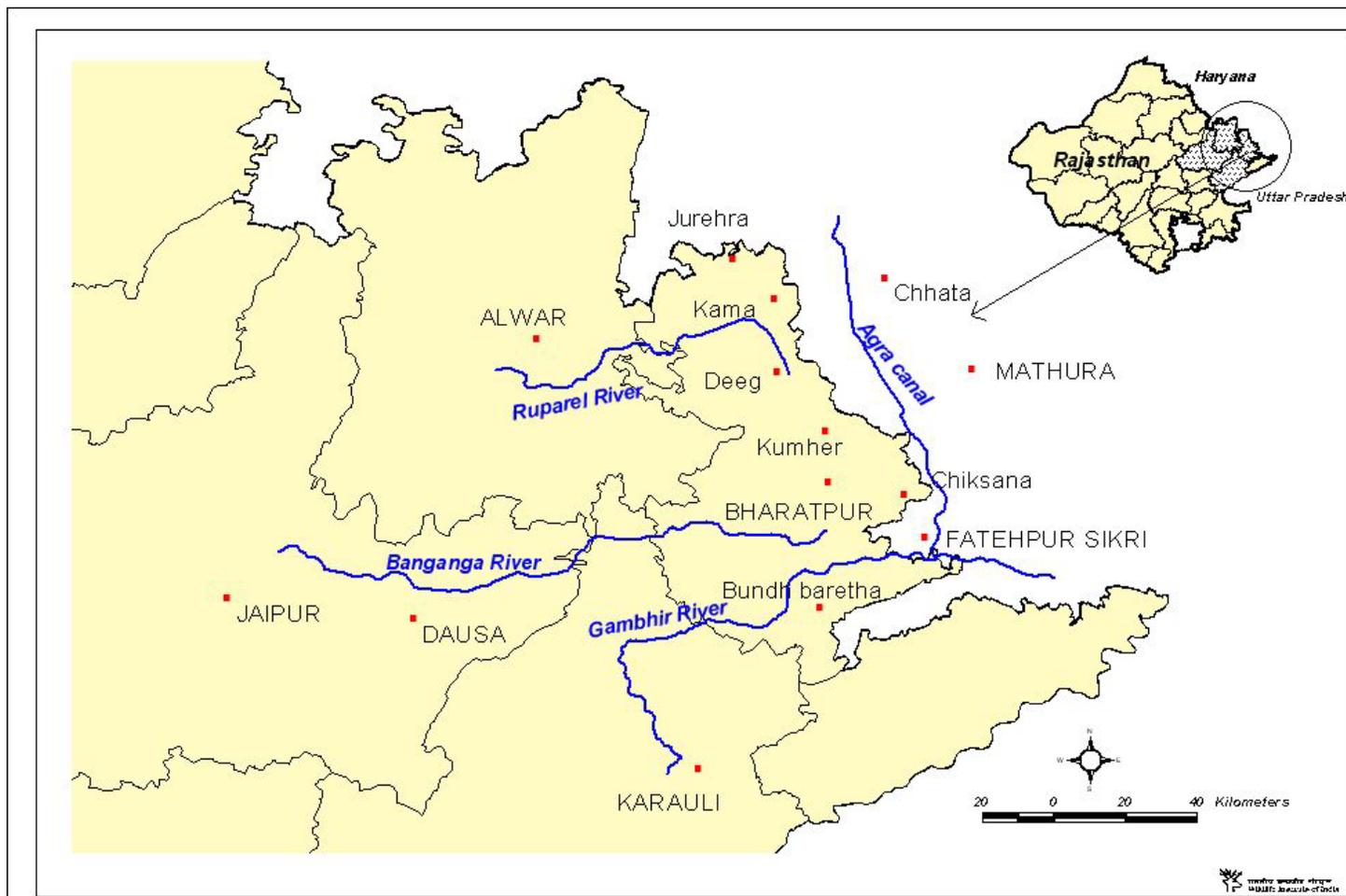


Figure. 2. Major Rivers in the catchment of Keoladeo National Park, Bharatpur

4. Methodology

4.1. Road transect method

Road transect method has been very useful for counting raptors ranging in wider areas (Fuller and Mosher 1987). This method was employed to determine raptor species distribution and their relative abundance in Keoladeo National Park. Roads and trails in the park provided convenient access to the study area were used as transects for survey (Figure 1) carried out monthly in clear weather by a two member team about an hour after sunrise from a moving vehicle (with speed 20 km/hr) stopped at specified points to count flying and perched birds. This allowed large areas of the park to be searched efficiently for raptors. A pair of good binoculars and spotting scope was used to aid identification of distant birds.

4.2. Direct count method

Nesting population of heronry species was estimated using complete direct count (Gaston 1975, Erwin 1980) of the colony sites in August 2005. The count was carried out about an hour after sunrise in a clear weather by a team of three persons (including two forest staff members). The boat was also used in areas inaccessible by foot during counting. Data was collected on colony size and composition. The numbers of active nests (with birds either incubating or making nest) per tree were counted for different heronry species. Presently, the heronry existed in the wetlands blocks – K, D, B and L in the park (Figure 1). Information was also recorded on the nest habitat use; nesting tree species, height, dbh and canopy size.

4.3. Satellite wetlands survey around Keoladeo National Park

A survey was carried out around KNP within its 100 km radius for documenting small and large satellite wetlands of significance especially for Palearctic Migratory Waterfowls and other aquatic birds. A team of four persons participated in the survey. At each site, information was collected on; the size of water-body, water-holding period, bird species composition and abundance. Survey locations were selected generally on the course of rivers such as Ruparel, Banganga, and Gambhir which form catchments of Keoladeo National Park and cater to its water requirements.

5. Results

5.1. Raptor community in the park

A total of 120 individuals were recorded representing 18 raptor species in seven months from December to August during the present study (Table 2). There were seven migrants and 11 resident raptor species. Among migrants, the Greater-spotted eagle was sighted commonly whereas Egyptian vultures and Honey buzzards were common resident raptor species sighted during these months (Table 2). Maximum migratory raptors were observed in December and they have completely left the park by May and thereafter resident raptors prevailed. The month of December was found to be holding maximum raptor abundance and species richness followed by April and the June was the month showing the lowest raptor abundance and species richness (Table 1).

Of two species of kites recorded from the park, Black-shouldered kite was commonly sighted. Three species of vultures were recorded during these months, common being Egyptian vulture followed by King vulture. The Long-billed vultures showed up only once in April (Table 2). Of all raptor species, eagles predominated. A total of seven species were reported; 3 resident and 4 migrants. Resident Lesser spotted eagle showed a regular movement in the park with maximum sightings in grassland habitats i.e. Block G and L whereas the Greater spotted and Imperial eagles inhabited the wetlands in the park especially Block E (Figure 1). Of two buzzard species, Honey buzzard was a common sighting. Harriers were represented by two species i.e. Eurasian Marsh and Pallid harriers. (Table 2).

Table 1. Month wise raptor population and species richness recorded in Keoladeo National Park, 2004-2005.

Months	Raptor population	Species richness	Resident Vs Migratory species
December 2004	29	12	42% : 58%
March 2005	17	8	75% : 25%
April 2005	28	9	89% : 11%
May 2005	17	6	83% : 17%
June 2005	6	4	100% : 0%
July 2005	10	5	100% : 0%
August 2005	13	7	100% : 0%

Table 2. Monthly abundance and species composition of raptors in KNP during 2004-2005.

Resident species	December	March	April	May	June	July	August	Total
Black kite <i>Milvus migrans</i>			1			1		2
Black-shouldered kite <i>Elanus caeruleus</i>	8	1	1		3		1	14
Egyptian vulture <i>Neophron</i>	1	5	6	7		2	1	22
Longbilled vulture <i>Gyps indicus</i>			6					6
King vulture <i>Sarcogyps calvus</i>		2	2	1	1		2	8
Lesser-spotted eagle <i>Aquila pomarina</i>	2	2	5	1	1	3	2	16
Short-toed eagle <i>Circaetus gallicus</i>			1					1
Bonelli's eagle <i>Hieraaetus fasciatus</i>	1				1			2
Honey buzzard <i>Pernis ptilorhynchus</i>	1	3	4	4		1	4	17
White-eyed buzzard <i>Butastur teesa</i>							2	2
Shikra <i>Accipiter badius</i>		2	2	2		3	1	10
Total	13	15	28	15	6	10	13	100
Migratory species								
Eurasian Marsh harrier <i>Circus</i>	2	1	0	0	0	0	0	3
Pallid harrier <i>Circus macrourus</i>	2	0						2
Imperial eagle <i>Aquila heliaca</i>	3							3
Greater-spotted eagle <i>Aquila clanga</i>	6	1						7
Steppe eagle <i>Aquila nipalensis</i>	1							1
Crested serpent eagle <i>Spilornis cheela</i>	1							1
Common kestrel <i>Falco tinnunculus</i>	1			2				3
Total	16	2	0	2	0	0	0	20
Grand total	29	17	28	17	6	10	13	120

5.2. Heronry colonies and their population

There were four colonies of heronry species in the park; one each in Block – K along Ghana canal, D, K, B and Lw. A total of 1459 active nests comprising 12 heronry species were recorded during August 2005 (Table 3). The species nesting included Indian Shag *Phalacrocorax fuscicollis*, Little Cormorant *Phalacrocorax niger*, Large Egret *Casmerodius albus*, Median Egret *Mesophoyx intermedia*, Little Egret *Egretta*

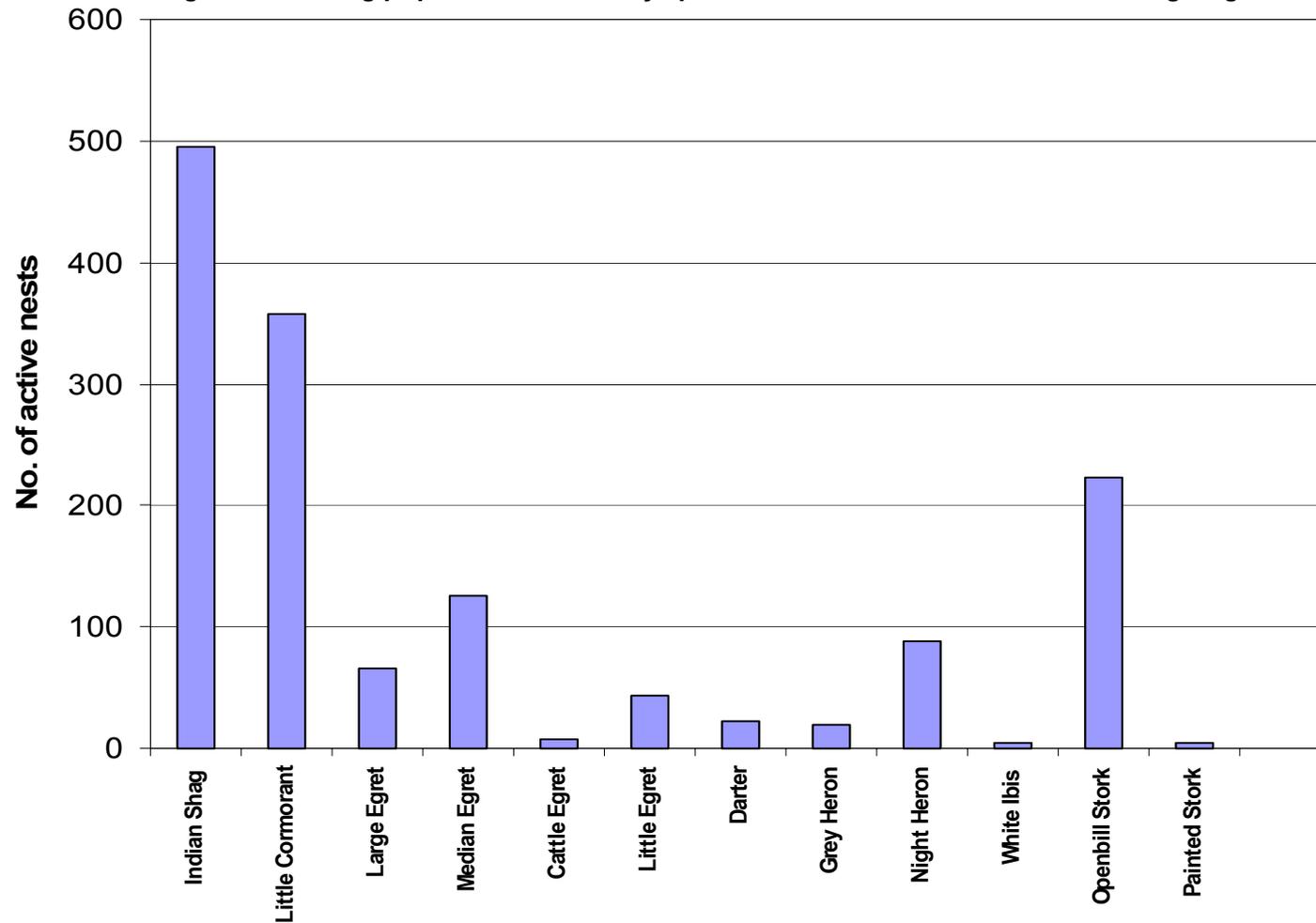
garzetta, Cattle Egret *Bubulcus ibis*, Darter *Anhinga melanogaster*, Black-crowned Night-Heron *Nycticorax nycticorax*, Grey Heron *Ardea cinerea*, Painted Stork *Mycteria leucocephala*, Open-bill Stork *Anastomus oscitans*, Oriental White Ibis *Threskiornis melanocephalus*. Indian Shags had the maximum number of nests (495) followed by Little cormorants (358) and Open-bill storks (223). Cattle egrets had the lowest number of nests (8). A large number of Painted storks (340) had arrived in the park by mid August, however nesting attempt was recorded in five pairs only (Fig. 3).

Trees such as *Prosopis juliflora*, *Acacia nilotica* and *Salvadora persica* were used for building nests. Of 40 trees counted holding all of counted nests, *Prosopis* – an exotic invasive species was found to be supporting maximum number of nests (62%). *Acacia* trees supported 33% of the nests and *Salvadora* trees 4%. White Ibis and Painted storks exclusively utilized *Acacia* trees for making their nests. It was found that tall trees with large canopy and dbh supported maximum number of nests (Table 3).

Table. 3. Characteristics of trees holding nests over 50 in KNP during August 2005.

Tree species	height (m)	Canopy size (m)	Dbh (cm)	Average no. of nests
<i>Prosopis juliflora</i>	8.6 ± 1.8	7.9 ± 0.6	55 ± 5	74 ± 20 (60 – 97)
<i>Acacia nilotica</i>	10.8 ± 2.1	6.7 ± 0.5	71.3 ± 2.5	57 ± 14 (50 – 79)

Figure 3. Nesting population of heronry species in Keoladeo National Park during August 2005



5.3. Survey of wetlands around Keoladeo National Park

Many small and large wetlands were surveyed around KNP within its 100 km radius. Many pools, canals and reservoirs were found full of water which had been dry for over a decade due to drought conditions prevalent in the region. In all, 14 satellite wetlands were surveyed.

To the north of KNP, wetlands surveyed were Bhandor, Babula, Bhatawali in Kumher, Nonera in Kama bordering Haryana. Many migratory birds both local and long distance migrants were found here. Avocets were the main attraction which was only recorded from here. To the south of KNP, we visited Pichuna canal in Rupbas, Sevla head and Bundh Baretha. The Bundh Baretha was holding water to its full capacity however no migratory waterfowls had arrived. To the east of KNP, the wetlands surveyed included Chiksana bundh, Terah mori, Nari-semri and Aanjnokh. A large congregation of Greater Flamingos (*Phoenicopterus roseus*) was reported from Aanjnokh depression (c 200 individuals). Small numbers of these birds were also recorded from Nari Semri and Nonera wetlands. Because of the Greater Flamingo's unique filter feeding mechanism; it is a bio-indicator species and a useful measure of ecosystem health of wetland systems. Their diet changes as the salinity of the salt ponds and marshes varies. However, nothing is known about its status in the region. The wetlands surveyed to the west of KNP namely Motijheel and Kalakoh bundh (Dausa district) were found full of water. The water of the river Banganga is stored here which is later used for irrigation and drinking.

We recorded few long distance palearctic migratory bird species during the present survey. Among migratory waterfowls only Garganey Teal (*Anas querquedula*) had arrived and other migrants mainly small waders sighted were Marsh Sandpiper (*Tringa stagnatilis*), Common Greenshank *Tringa nebularia*, Green Sandpiper (*Tringa ochropus*), Wood Sandpiper (*Tringa glareola*), Ruff (*Philomachus pugnax*), Pied Avocet (*Recurvirostra avosetta*), and Little Ringed Plover (*Charadrius dubius*). The details of the satellite wetlands including avifaunal diversity are provided in Table 4.

Table 3. Details on the status of satellite wetlands found around KNP during August 2005 along with the information on their avifauna.

SN	Survey site	Location	Size in km (Approx.)	Water depth (in metres)	Water lasting period	Migratory water birds and others	Resident water birds
1	Bhandor	Kumher	2x2	2.1	Up to December	Garganey teals (25), coot (1)	Spotbills (2)
2	Babula	Kumher	2.5x2.5	2.3	Up to November	Little-ringed plovers (5), Ruff (25), Spotted sandpiper (3)	Combduck (3)
3	Bhatawali	Kumher	3x3	-	Up to September	-	Combduck (2)
4	Nonera	Kaman	3.5x3.5	-	Up to February	Greater Flamingo (7), Pied Avocet (8), Wood sandpiper (5), Marsh sandpiper (4), Greenshank (2)	Little cormorant (20), Indian River Tern (5), Shag (9), Cattle egret (3), Sarus crane (2)
5	Pichuna	Rupbas	-	-	Up to November	-	Cattle egret (2)
6	Sevla	Bayana	-	-	Up to December	-	-
7	Baretha	Bayana	5x5	-	Perennial	-	Chestnut bittern, Little cormorant (2), Purple heron (1)
8	Chiksana	Chiksana	2x2	1.3	Up to January	Ruff (4)	Grey heron (3), Painted stork (4), Combduck (1), Cattle egret (80)
9	Terah mori	Fatehpur sikri	3x3	2.7	Up to October	Whiskered tern (2)	Combduck (2), Spotbill (1), Little cormorant (7), Indian river tern (2)
10	Nari semri	Mathura	2x2	-	Up to January	Greater Flamingo (5)	Painted stork (4), Oriental white ibis (2), Median egret (6), Grey heron (5), Large egret (2), Shag (150), Darter (5), Black-winged stilt (15), Little cormorant (12), Indian river tern (2)
11	Aanjnokh	Chhata	1x1	-	Up to November	Greater Flamingo (200)	Little grebe (2), Little cormorant (2), Cattle egret (4), Grey heron (3), Median egret (2), Black-winged stilt (20), Purple moorhen (1), Spotbill (2)
12	Motijheel	Sevar	1.5x1.5	-	Up to December	-	Little cormorant (2)
13	Kalakoh	Dausa	4x4	5.7	Up to December	Pied crested cuckoo (2)	Little cormorant (2), Little egret (1), Large egret (1), Grey heron (1)
14	Ajan bund	Bharatpur	3x3	3.2	Up to October	Green sandpiper (1)	Openbill (1), Pond heron (1), Cattle egret (18), Grey heron (1)

6. Discussion

6.1. Importance of satellite wetlands

The first step in conservation of biodiversity is to assess the diversity of natural resources present and identify those, which are important and most irreplaceable. The Keoladeo National Park – a natural world heritage site is known worldwide for its large concentration of western Palearctic migratory waterfowls which arrive every winter. These birds initially spread all around the park occupying all possible large and small wetlands habitats enriched with abundant food resources. These wetlands are found all along the courses of three rivers namely Ruparel, Banganga and Gambhir which pass through Bharatpur and converge in to the River Yamuna. However, there is no information available on the present status of these wetlands and how and when they play crucial role for the survival of wild species. The KNP being a small wetland cannot meet all the biological and ecological requirements of birds arriving to here. However, it provides optimal conditions for roosting of birds due to strict protection provided to it. KNP is partly dependent on rains and water from the catchments. In the recent past there have been many instances when the park did not receive sufficient water from its catchments as by making check dams and canals villagers had directed water towards their agricultural farms for irrigation. Also, during the period of erratic and low rainfall the park remains mostly dry and birds have been recorded moving out in search of optimal habitats. In 2004, when drought conditions prevailed in Bharatpur and few birds arrived in the park there were many thousands present at such one of satellite wetlands in Nonera about 70 km from the park. Wetlands clearly play a crucial role in the population dynamics of many avian populations, and such wetlands, large and small, need to be efficiently managed. Studies done elsewhere have indicated that it is on the small isolated sites that most of the regional populations depend and therefore such sites must be intensely managed (In Kushlan 1986). Small wetlands, often unrecognized as important for conservation, provide valuable feeding sites and migration staging posts along flamingo migration routes. This highlights the need for the conservation of the network of small wetlands (McCulloh and et al. 2003). Therefore the present survey is a step in a right direction to collect baseline information on the importance of such wetlands to the migratory birds coming to the region and thereby designing a conservation strategy from a landscape perspective. In recent

years conservation strategies were developed for North America's waterfowl and shore birds (Anonymous 1986) primarily to protect especially important staging and wintering areas that are critical for the survival of many species, which nest widely scattered across arctic habitats but which often become concentrated during migration and winter (Parnell *et al.* 1988). All of our efforts will fail towards conservation of wildlife in KNP unless the diverse wetland habitats in its vicinity required by many species are maintained in healthy condition. Therefore a concrete conservation strategy especially for migratory waterfowls depending on resources lying outside the park is urgently required.

6.2. Monitoring heronry and raptor communities

Aquatic birds can play an important role in wetland management in that they are extremely sensitive to hydrological fluctuations. Such sensitivity can be used to set management goals for the wetlands. The strong association of heronry birds with aquatic ecosystems make these birds excellent barometers of environmental health. It is therefore crucial that a systematic effort be made to maintain and monitor populations and understand the factors that affect population fluctuations. Information on the effects of water management on avian population parameters is urgently needed for most wetlands types. Understanding the relationships of wetland birds to management strategies will allow managers to take the needs of aquatic birds into consideration (Kushlan 1986). Of 12 species found breeding in the park Painted storks, Oriental white ibis and Darter are considered globally as near threatened birds (IUCN 2004) and therefore require special attention. *Acacia nilotica* has been identified as an important tree for nesting of two globally near threatened species i.e. Oriental white ibis and Painted storks (IUCN 2004). They probably require resilient species which can support their heavy weight and therefore play a crucial role in the species survival and demands for long term research relative to their habitat use.

Raptor monitoring provides a useful index to assess overall health of the park ecosystem as they are widely distributed in almost all kinds of habitats. The number of raptors in December was relatively high both in abundance and species richness followed by April (Table 1). This was due to the presence of migratory raptors in the park during this month. In April, the resident raptors, both within and around the park

increased. Vultures both White-backed *Gyps bengalensis* and Long-billed *G. indicus* are still the most threatened. During present study, only once the Long-billed vulture was observed in April. The low raptor species richness and abundance recorded during present study against the very high species richness and abundance observed during 1996-2000 (Verma 2002) was due to the drought conditions prevalent for the last four years in KNP.

7. Future activities

- Population dynamics: One of the first step in evaluating trends is to assess reproductive success. The reproductive success in the heronry colonies will be monitored. For this, attempts will be made to determine the young fledged per nest.
- There is a strong need for research on ecosystem management. This relates primarily to increasing our knowledge of the relationships between colonial waterbirds and their environments, especially with respect to the availability of adequate food supplies and habitat.
- Ecological studies: Further research is required to provide information on the reproductive strategies and environmental factors affecting reproductive success. Variables that are worthy of monitoring in case of subsequent population decline are environmental contaminants in food sources, movement patterns and foraging habitat by nesting and wintering birds.
- Monitoring of raptors communities will be continued for estimating relative abundance, distribution patterns and habitat use.
- Quantifying the dependency of aquatic birds on the satellite wetlands around KNP will be carried out by monitoring waterfowls between both the habitats i.e. wetlands in the park and surrounding areas upto 200 km.

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Appendix I
Glimpses of Keoladeo National Park



Panoramic post monsoon view of KNP



View of Herony colony along Ghana canal in KNP



Openbill storks and egrets colony in Block - K



Painted stork colony in Block - B



Water-lily in the wetlands of KNP



Kadam tree in full bloom

Appendix II

Glimpses of satellite wetlands around Keoladeo National Park



Ajan bundh – a temporary reservoir which supplies water through Ghana canal to KNP



An outlet –Terh mori in Fatehpur Sikri allows to pass excess waters from River Gambhir to Yamuna in Uttar Pradesh



Kalakoh bundh – a dam on the River Banganga also nurtures myriads of migratory waterfowls



Bundh Baretha, a perennial large reservoir serves as staging and wintering ground for migratory waterfowls



Chiksana bundh – a winter refuge for migratory waterfowls



Aanjnokh wetland – a winter resort to Greater Flamingos