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Article

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Population status and species diversity of wetland birds in the Rapti and Narayani rivers and associated wetlands of Chitwan National Park, Nepal

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Abstract: In autumn and winter, 24 migratory waterfowl species from the north utilise the wetlands of Chitwan National Park, which provide vital staging, roosting, resting, foraging and breeding places. The birds stay for about eight months before returning north in March and April. These birds are indicators of healthy wetlands, and they distribute nutrients through their droppings that increase primary production of aquatic vegetation and fish. A population census of wetland birds was conducted during January 2014 in Chitwan National Park on the Rapti and Narayani rivers and associated wetlands, including Lami Tal, Tamor Tal, Garud Tal, Devi Tal and marshes and lakes around Temple Tiger. The study found that the Ruddy Shelduck *Tadorna ferruginea* was the migratory waterfowl with the largest population in these rivers.

Keywords: Chitwan National Park, Narayani River, Rapti River, Ruddy Shelduck, species diversity, wetlands.

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INTRODUCTION

Wetlands are productive ecosystems that are ideal for migratory waterfowl and other vertebrate fauna (Acharya 2002; WBC 2006). The wetlands of Chitwan National Park (CNP) provide habitats for endangered mammals that include the Greater One-horned Rhinoceros *Rhinoceros unicornis*, Tiger *Panthera tigris*, Leopard *Panthera pardus*, Gaur *Bos gaurus*, Sloth Bear *Melurus ursinus* and Gangetic Dolphin *Platanista gangetica.* The wetlands are also home to the Critically Endangered Gharial *Gavialis gangeticus* and to Marsh Mugger Crocodiles *Crocodylus palustris*, Asiatic Rock Python *Python molurus* and many threatened bird species.

Chitwan National Park wetlands provide breeding, staging, roosting and feeding sites for migratory and non-migratory birds. Eight-hundred-and-eighty-four (884) bird species have been recorded in Nepal, of which 39 are globally threatened (Grimmett et al. 2016), and 625 bird species have been recorded in Chitwan District, of which 24 are globally threatened (BES 2013) and 120 are wetland-dependent. Nepal harbours a total of 195 wetland-dependent bird species, with the Terai wetlands supporting 187 species (Thapa 2006). Chitwan National Park and buffer zones have been identified as an "Important Bird Area" owing to species richness and the high diversity of bird habitats (BCN and DNPWC in prep.). Beeshazari and its associated lakes lie in Chitwan's buffer zone, and is an internationally renowned Ramsar site. CNP is drained by three rivers: Reu—the smallest, which marks the park boundary on the south-east, Rapti—the second largest, which forms the northern boundary of the eastern portion of the park and the Narayani River—the largest which delineates the western part of the park boundary. The Narayani flows to India via the barrage at Tribenighat and is the third largest river in Nepal. The riverine flood plains of the Narayani, Rapti and Reu with oxbow lakes, marshes, and swamps provide suitable habitat conditions for wetland-dependent birds. Wetland birds are key indicators of wetland ecosystems and are considered important in monitoring environmental issues (Urfi et al. 2005). Migratory and non-migratory waterfowl are important species of wetland biodiversity (Wei & Mundkur 2004).

Wetland birds are under considerable pressure from siltation/sedimentation, eutrophication, invasion of alien species, industrial pollution and litter disposal, intensification of agriculture, land encroachment and deforestation, over-fishing and human disturbances in the river basins (Shah 1997; Bhandari 1998; IUCN 2004; Acharya & Rajbhandari 2012; Rajbhandari & Acharya 2015). Within CNP and the buffer zone, 35 wetlands are heavily affected by more than 50% water coverage by Water Hyacinth *Eichhornia crassipes,* Duck Weed *Pistia stratiotes,* Cut Grass *Leersia hexandra,* Shrubby Morning Glory *Ipomoea carnea* ssp. *fistulosa*. Devi Tal is encroached by about 95% by *Eichhornia crassipes* (CNP 2015). These invasive species pose serious threats to wetland bird species, apart from species such as Jacanas and Gallinules. Coverage of the open water surface of pools and lakes by invasive species has resulted in the loss of foraging areas for dabbling ducks and other wetland birds (Dahal 2007). In addition, when large areas of water are covered by these invasive species less light is able to reach below the surface, resulting in poor growth of other aquatic plants. This leads to low oxygen levels in the water, which results in reduced populations of aquatic invertebrates that are food for waterfowl. Water Hyacinth and Water Cabbage *Pistia stratiotes* are washed away from lakes and swamps into the Narayani and Rapti Rivers. These plants can be seen floating and spreading at the edges of rivers and feeder streams, where they cause loss of habitat for waterbirds, particularly dabbling ducks. Pollutants such as plastics, pesticides, industrial effluent and persistent organic pollutants (POPs), intensive fishing with the use of gillnets, electric shock and poisoning are common in the rainy season in smaller streams and are potentially harmful to aquatic birds, turtles, dolphins, crocodiles and other non-target species. Poisoning of rivers and wetlands affects wetland bird species directly through poisoning and also indirectly as a result of food scarcity (Baral & Inskipp 2004).

This paper highlights the population trends and threats to the migratory and non-migratory birds in the rivers and wetlands of CNP.

STUDY AREA AND METHODS

This study was carried out in the wetlands of CNP that included the Narayani, Rapti and Reu Rivers and its floodplain lakes and marshy areas (Garud Tal, Lami Tal ,Tamor Tal, Devi Tal and Temple marshy area). CNP ($27^0$16'56"–$27^0$42'14"N & $83^0$50'23"–$84^0$46'25"E) with an area of 932km² has diverse terrestrial and aquatic ecosystems over elevations ranging from 110–850 m. The climate is subtropical and the region receives high precipitation during the monsoon season. The temperature reaches up to 38^0C in summer (June–July) and drops to 6^0C during winter (December–January).

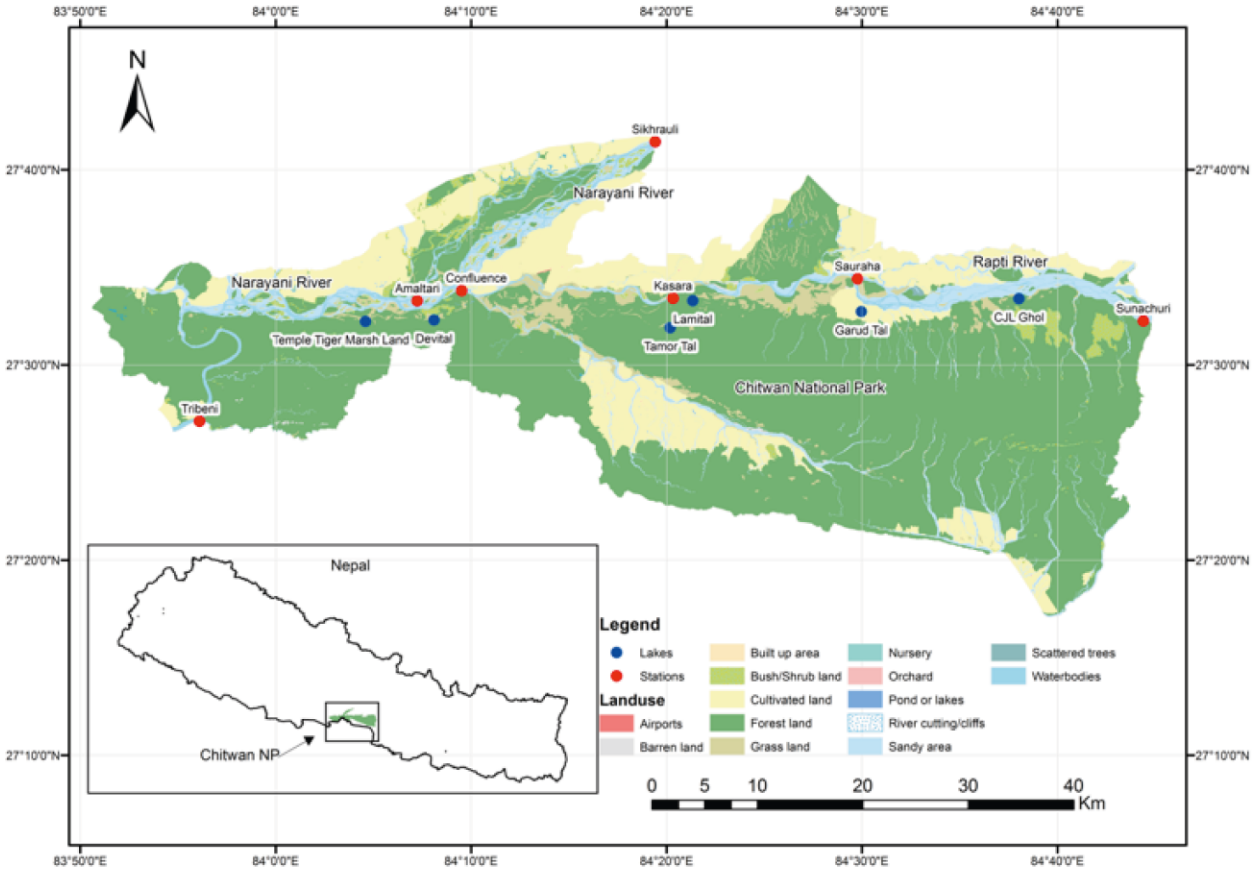

Figure1. Study area showing Rapti and Narayani Rivers and their associated wetlands

About 70% of the park area is covered by *Shorea robusta* forest, and the remaining area is characterized by grasslands and riverine forests. The Narayani, Rapti, Reu are the major rivers and their floodplains include oxbow lakes, marshes and swamps (Fig. 1).

This study was conducted during January 2014 in the Rapti and Narayani rivers and their associated wetlands. The study area was divided into six sectors (3 in the Rapti, 71.6 km; 3 in the Narayani, 101.4km), such that each sector could be surveyed within one day (Khadka 2005, 2010, 2011, 2012). The six sectors comprised: Zone A (Sunachari-Sauraha), Zone B (Sauraha-Kasara), Zone C (Kasara-Rapti/Narayani confluence), Zone D (Sikrauli-Amaltari/western channel), Zone E (Sikrauli-Amaltari/eastern channel) and Zone F (Amaltari-Tribeni). Within the six sectors, the Garud Tal (8.8ha), Tamor Tal (14.12ha), Lami Tal (2.94ha), Devi Tal (7.55 ha), and Temple Tiger marsh (8.15ha) were surveyed using elephants and walking along the perimeter of the lake in accessible areas with two citizen scientists and two experienced ornithologist.

Population counts

Two non-motorized wooden dugout canoes were used to make the population counts of waterfowls in the Rapti and Narayani rivers and their floodplain wetlands. Surveys were conducted in the mainstreams of Rapti and Narayani (71.6km in Rapti and 104.1km in Narayani) with four experienced ornithologists and four citizen scientists focussed on both sides of the boat by transect count. Counting of birds on either bank in each sectors of river was completed in one day. The research team spent 38.15hr in six days for survey in a range of 5–7.3 hours. The speed of the travel was in a range of 3.97 km/hr to 5.86km/hr depending on length of river segments. The survey was completed within six days. In each sectors of the Rapti and Narayani Rivers survey were carried out only one time. Population counts in Garud Tal (8.8 ha), Tamor Tal (14.12ha), Lami Tal (2.94ha), Devi Tal (7.55ha) and Temple Tiger Marshes (8.15ha) were done by using elephants in inaccessible areas and counts were done from the vantage point and walking along the perimeter of the lake in the accessible areas. The wetlands of all the six sectors were surveyed by the

Table 1. Survey sectors within the Rapti and Narayani Rivers

Date	River	Survey sites and GPS locations						Length (km)
		From	Easting	Northing	To	Easting	Northing	
19.i.2014	Rapti	Sunachuri	84.740153°	27.537571°	Sauraha	84.496418°	27.573566°	29.00
20.i.2014	Rapti	Sauraha	84.496418°	27.573566°	Kasara	84.339090°	27.556899°	20.20
21.i.2014	Rapti	Kasara	84.339090°	27.556899°	Rapti/Narayani Confluence	84.158703°	27.563450°	22.40
22.i.2014	Narayani	Sikhrauli	84.323735°	27.690551°	Amaltari via western channel	84.120833°	27.554696°	28.20
23.i.2014	Narayani	Sikhrauli	84.323735°	27.690551°	Amaltari via eastern channel	84.120833°	27.554696°	30.40
24.i.2014	Narayani	Amaltari	84.120833°	27.554696°	Tribeni	83.935182°	27.451963°	42.80

other team which included two citizen scientists and two ornithologists counting birds by point count method. Typically surveys were carried out between 10:30hr and 17:30hr, but during the periods of foggy weather, surveys were delayed until visibility was good (up to a distance of 100m) and sufficient light available. The research team spent 5–6 hours in each lake area using elephants and walking along trails. Each lake could be surveyed within one day. The survey area ranged from Sunachuri, at the eastern border of the park to Tribeni, at the international border with India. The route taken was from Sunachuri to the Rapti Narayani confluence and upstream along the eastern channel of the Narayani via Sikraulighat to the western channel of the Narayani to Tribeni including shallow branches of the Narayani River (Table 1).

7x35 Olympus DPSR binoculars and 10x50 DPS1 Olympus were used for bird identification. Photographs were taken and videos were recorded using a Canon Powershot 5x40 HS camera to facilitate identification of some bird species.

The Shannon index of general diversity was used to compare the diversity of different wetland birds (Odum 1971; Yadav et al. 1987).

Shannon index of general diversity $\bar{H}$

$\bar{H}=-\sum(ni/N)\log(ni/N)$

Or

$-\sum P_i \log P_i$

Where ni= importance value for each species

N=total of important values

P_i=importance probability for each species=ni/N

Maximum possible diversity

$H_{max}= \log_2 k$ or $H_{max}=3.3219\log_{10} k$ where k = No. of species present at the site and H_{max}=maximum species diversity

Relative diversity

$J = H/ H_{max}$

J is relative diversity

RESULTS AND DISCUSSION

Population status

A total of 994 individuals of the Oriental Darter *Anhinga melanogaster* and cormorant species were recorded in CNP, of which 578 birds were observed in Zone F (Amaltari-Tribeni). This figure accounts for 58.14% of the total count of these species (Table 2). Egrets and herons were most abundant in Zone F accounting for 50.24% of the total count of 412 birds (Table 3). The distribution of storks in CNP was more or less similar to that of Darter and cormorant species, with the largest number of individuals in Zone F, which accounts for 20.43% of the total count of storks (Table 4). Zone E supported the largest number of individuals of geese and ducks with a count of 2,319 birds, which represents 25.35% of the total count of these species. The distribution of these birds was more or less similar in other zones (Table 5). This may be because this zone is characterizedby numerous small feeder streams, which provide important basking and roosting sites. The largest numbers of individuals were recorded in Zones B and C, which respectively accounted for 73 and 70 birds representing 32.58% and 31.25% of the total count (Table 6).The highest number of 1,273 birds was recorded in Zone D, which represented 29.87% of the total count of 4,261 individuals (Table 7). Raptors wereobserved in very low numbers. Only 18 individuals of fish-eating birds were observed (Table 8).

Habitat status

During the study period, the following wetland areas of CNP were mostly used by the waterbirds:

Table 2. Population status of darter and cormorant in CNP during January 2014

Scientific name	A	%	B	%	C	%	D	%	E	%	F	%	Total	Mean & SD
Anhinga melanogaster	5	15.62	7	21.87	9	28.12	3	9.37	4	12.50	4	12.50	32	5.33±2.055
Phalacrocorax niger	4	21.05	6	31.57	2	10.52	0	0	0	0	7	36.84	19	3.167±2.734
Phalacrocorax carbo	15	1.59	67	7.10	11	1.16	129	13.67	154	16.33	567	60.12	943	157.167±190.82
Total	**24**		**80**		**22**		**132**		**158**		**578**		**994**	

Table 3. Population status of egrets and herons in CNP during January 2014

Scientific name	A	%	B	%	C	%	D	%	E	%	F	%	Total	Mean & SD
Egretta garzetta	11	18.33	5	8.33	22	36.66	3	5	5	8.33	14	23.33	60	10±6.583
Casmerodius albus	6	14.63	2	4.87	12	29.26	7	17.07	3	7.31	11	26.82	41	6.833±3.716
Mesophoyx intermedia	1	2.43	5	17.24	9	31.03	3	10.34	4	13.79	7	24.13	29	4.833±2.609
Bubulcus ibis	0	0	5	27.77	13	72.22	0	0	0	0	0	0	18	3±4.83
Ardeola grayii	15	26.78	7	12.5	15	26.78	5	8.92	7	12.5	7	12.5	56	9.33±4.07
Butorides striatus	4	17.39	3	13.04	3	13.04	3	13.04	4	17.39	6	26.08	23	3.83±1.067
Nycticorax nycticorax	0	0	0	0	0	0	0	0	5	3.08	157	96.91	162	27±58.17
Ixobrychus cinnamomeus	1	50	0	0	0	0	0	0	0	0	1	50	2	0.33±0.471
Ardea cinera	3	23.07	3	23.07	0	0	4	30.76	2	15.38	1	7.69	13	2.167±1.344
Ardea purpurea	1	12.5	2	25	1	12.5	1	12.5	0	0	3	37.5	8	1.33±0.943
Total	**42**		**32**		**75**		**26**		**30**		**207**		**412**	

Table 4. Population status of storks in CNP during January 2014

Scientific name	A	%	B	%	C	%	D	%	E	%	F	%	Total	Mean & SD
Anastomus oscitans	6	14.28	8	19.04	13	30.95	0	0.00	2	4.76	13	30.95	42	7±4.97
Ciconia episcopus	1	3.22	3	25.00	7	22.58	3	9.67	5	16.12	12	38.07	31	5.167±3.58
Ciconia nigra	10	12.98	6	7.79	3	3.89	27	35.06	21	27.27	10	12.98	77	12.83±8.43
Leptoptilos javanicus	6	16.66	13	36.11	8	22.22	4	11.11	2	5.55	3	8.33	36	6±3.697
Total	**23**		**30**		**31**		**34**		**30**		**38**		**186**	

Table 5. Population status of Geese and Ducks in CNP during January 2014

Scientific name	A	%	B	%	C	%	D	%	E	%	F	%	Total	Mean & SD
Dendrocygna javanica	0	0	137	74.86	27	14.75	0	0	0	0.00	19	10.38	183	30.5±48.7±81
Tadorna ferruginea	1385	18.40	1012	13.48	1099	14.65	1269	16.92	1653	22.04	1081	14.41	7499	1249.83±219.47
Anas strepera	87	24.03	0	0	44	12.15	15	4.14	19	5.24	197	54.41	362	60.33±67.15
Anser indicus	0	0	0	0	5	1.31	9	2.36	365	96.05	1	0.26	380	63.33±134.95
Anas platyrhynchos	90	51.18	0	0	13	7.38	7	3.97	17	9.65	49	27.84	176	29.33±31.21
Anas crecca	2	0.70	0	0	0	0	59	20.92	221	78.36	0	0.00	282	47±80.697
Anas acuta	12	57.14	0	0	9	42.85	0	0	0	0	0	0	21	3.5±5.025
Mergus merganser	45	22.05	5	2.45	42	20.58	17	8.33	44	21.56	51	25	204	34±16.85
Aythya farina	0	0	1	7.14	13	92.85	0	0	0	0	0	0	14	2.33±4.784
Rhodonessa rufina	1	10	0	0	0	0	0	0	0	0	9	90	10	1.667±3.3
Aythya fuligula	4	100	0	0	0	0	0	0	0	0	0	0	4	0.667±1.5
Anas penelope	0		0	0	0	0	0	0	0	0	11	100	11	1.833±4.1
Total	**1626**		**1155**		**1252**		**1376**		**2319**		**1418**		**9146**	

Table 6. Population status of waterhen and moorhen in CNP during January 2014

Scientific name	A	%	B	%	C	%	D	%	E	F	%	Total	Mean & SD
Amaurornis phoenicurus	1	12.5	5	62.5	0	0	0	0	0	2	25	8	1.33±1.8
Gallinula chloropus	17	9.13	58	31.18	67	36.02	9	4.83	0	35	18.81	186	31±24.77
Porphyrio porphyrio	0	0	2	100	0	0	0	0	0	0	0	2	0.33±0.745
Amaurornis akool	1	12.5	2	25	3	37.5	0	0	0	2	25	8	1.33±1.106
Fulica atra	7	35.00	6	30	0	0	0	0	0	7	35	20	3.33±3.35
Total	**26**		**73**		**70**		**9**		**0**	**46**		**224**	

Table 7. Population status of shorebirds, waders, and gulls in CNP during January 2014

Scientific name	A	%	B	%	C	%	D	%	E	%	F	%	Total	Mean & SD
Tringa totanus	65	79.82	3	3.65	4	4.87	3	3.65	2	2.43	5	6.09	82	13.67±22.98
Tringa nebularia	78	44.31	5	2.84	23	13.06	17	9.65	3	1.70	50	28.40	176	29.33±26.69
Tringa ochropus	9	22.5	5	12.5	5	12.50	8	20	6	15	7	17.5	40	6.67±1.491
Actitis hypoleucos	23	41.81	4	7.27	7	12.72	7	12.72	5	9.09	9	16.36	55	9.167±6.388
Callidris temminckii	1119	87.14	19	1.47	23	1.79	67	5.21	17	1.32	39	30.03	1284	214±405.09
Charadrius dubius	67	51.53	13	10	7	5.38	19	14.61	7	5.38	17	13.07	130	21.67±20.77
Glareola lactea	0	0	0	0	0	0	1142	47.30	521	21.58	751	31.11	2414	402.33±4.4281
Larus ichthyaetus	0	0	0	0	0	0	0	0	0	0	1	100	1	0.167±0.373
Vanellus duvaucelii	6	15.78	8	21.05	2	5.26	7	18.42	5	13.15	10	26.31	38	6.33±2.494
Vanellus indicus	10	24.39	9	21.95	12	29.26	3	7.31	2	4.87	5	12.19	41	6.833±3.716
Total	**1377**		**66**		**83**		**1273**		**568**		**894**		**4261**	

Table 8. Wetland-dependent raptors

Scientific name	A	B	C	D	E	F
Pandion haliaetus	3	1	1	2	2	1
Ichthyophaga ichthyaetus	2	2	1	1	0	2
Total	**5**	**3**	**2**	**3**	**2**	**3**

Sunachuri to Sauraha in Rapti River (Zone A)

Amrite, Jindagani, Icharni and Jayamangala areas have relatively low human disturbance resulting in relatively high bird abundance there. These areas are characterized by large stretches of mudflats, shingle banks, stony feeder streams and sand banks which are primarily used by birds for resting, roosting and feeding sites. This zone which includes Dudhaura, Charhara, Dumaria also includes potential sites for birds and sightings of good numbers of birds along the Rapti River were recorded.

Lami Tal and Tamor Tal are near the park headquarters at Kasara. TamorTal lies on the southern part of Kasara and LamiTal lies in the eastern part of Kasara near Ghatgain on the Rapti floodplain. Devi Tal, near Khoriya Muhan and the Temple marshy area south of Amaltari, were also intensively surveyed to determine the abundance and distribution of aquatic birds. Grey-headed Fish Eagle *Ichthyophaga ichthyaetus*, a wetland-dependent raptor and a very rare species in Nepal was recorded from these wetlands. Tamor Tal, Devi Tal and the marshes and swamps of Temple Tiger are primarily used by raptors for nesting (Khadka 2010). Other birds such as Lesser Whistling-duck *Dendrocygna javanica*, Common Moorhen *Gallinula chloropus*, Bronze-winged Jacana *Metopidius indicus* are common in the marshy areas of Lami Tal and Temple area. The marshes near Chitwan Jungle Lodge inside the park area are productive habitats and supported a significant population of wetland birds such as Common Moorhen due to food availability and the dense coverage aquatic plants. Associated aquatic predators such as Mugger

Image 1. Bar-headed Goose in Narayani River

Crocodile *Crocodylus palustris* have been recorded each year. This wetland was previously managed by the Temple Tiger hotel. However, following the new policy of the Nepal Government, all hotels inside the park were closed in 2013. After this, the wetland areas were highly threatened by human disturbances which resulted in a decline of aquatic bird populations.

The western channel of the Narayani River (Zone E)

Supported a high abundance of birds. Dibayapuri, lagain, Laukhani and Jagbohari of Lamichaur area are the core habitats (Khadka 2010).

A flock of Bar-headed Geese *Anser indicus* has been recorded on Laukhani Island in the western Narayani River channel every year. The geese are mostly seen feeding in marshy paddy fields early morning and afternoon around the Pithauli Village Development Committee (VDC) area, Nawalparasi District.A flock of Common Crane *Grus grus* has been seen every year in the BhaluTappu area on the eastern branch of Narayani. The cranes were also seen in Dibyanagar VDC, Chitwan where they use marshy paddy fields as feeding grounds (Khadka 2005, 2010, 2011 and 2012) (Image 1). Important habitats for birds in this zone were Ratanpur, Laindaghat, Seri Post area, Budardovan and Materi island. Well-used areas by waterbirds were found to be in the Rapti and Narayani Rivers, as well as major lakes, e.g., Garud Tal, Tamor Tal, Lami Tal and the marshy area of Temple Tiger, Bhalu Tappu areas, as well as at Dibyapuri, Lagain,Laukhani, Bhosar Ghat, Badruwa Ghat, Musar Ghat, Khoriya Muhan, Amaltari Ghat, Lainda Ghat, Seri, Budar Dobhan, and the Nuna areas of the Narayani River (Khadka 2013). According to this study, the reasons for bird concentrations in these areas were lower disturbance compared to other parts, the presence of many tributary confluences, many feeder streams in the main river, and algae covered stones where a variety of aquatic-invertebrates and small fish can hide. Other reasons could be the presence of the riparian habitats such assandy banks and forest along the river banks.

The eastern part from Amrite to Sunachuri of Rapti River (Zone A)

It has inadequate patrolling and monitoring. Here there were high human disturbances such as sand and stone mining, grazing, fish poisoning, fishing through electric shock and movement of people in the area. This has resulted in the loss of habitats and disturbance to aquatic birds. Therefore, very low numbers of waterbirds were recorded there. Human activities such as overfishing were higher in this area than elsewhere (CNP 2013,2014 records).

SikrauliGhat to AmaltariGhat of Narayani (Zones D & E)

The eastern channel of the Narayani River (Zone D) supported smaller numbers of waterbirds due to the high water current and lack of appropriate feeder streams compared to the western channel, although a flock of Common Crane *Grus grus* has been recorded each year during CNP bird monitoring (Khadka 2014).

Amaltari to Tribeni in Narayani (Zone F)

The Bagban to Tribeni (20km) stretch of the Narayani River had a high volume of running water with an average depth of 5.23m and a stagnant condition of the water channel due to the effects of the Gandak barrage at the Indo-Nepal border which is used for irrigation both in India and Nepal. The lack of feeding and roosting sites resulted in low abundance and diversity of birds. Great Crested Grebe *Podiceps cristatus* is mostly seen in the reservoir area and occasionally, a flock of Great Cormorant *Phalacrocorax carbo*, a few pairs of Ruddy Shelducks *Tadorna ferruginea* and wader species were seen (Khadka 2011).

Species Diversity

The species diversity of *A. melanogaster* and cormorants (Image 2) was highest in Zone C (H=1.342). The maximum species diversity was observed in Zones A, B, C and F representing same value (H_{max}=1.585). The relative measure of diversity of these species was highest in Zone C (J=0.847) (Table 9).

Among the egrets and herons, the value of species diversity was highest in Zone B (H=2.88). The maximum species diversity of these birds was also highest in Zone B (H max=3). Similarly, the value of relative measure was highest in Zone E (J=0.969) (Table 10).

Table 9. Species diversity of darters and cormorants

Zones	H	H_{max}	J
A	1.33	1.585	0.839
B	0.802	1.585	0.506
C	1.342	1.585	0.847
D	0.157	1	0.157
E	0.17	1	0.17
F	0.154	1.585	0.097

Table 10. Species diversity of egrets and herons

Zones	H	H_{max}	J
A	2.4178	2.999	0.806
B	2.88	3	0.958
C	2.481	2.807	0.884
D	2.64	2.807	0.94
E	2.72	2.807	0.969
F	1.432	3.17	0.452

Table 11. Species diversity of storks

Zones	H	H_{max}	J
A	1.73	2	0.865
B	1.828	2	0.914
C	1.84	2	0.92
D	0.936	1.585	0.5
E	1.31	2	0.65
F	1.851	2	0.925

Table 12. Species diversity of geese and ducks

Zones	H	H_{max}	J
A	0.889	3	0.296
B	0.575	2	0.288
C	0.84	3	0.28
D	0.538	2.585	0.208
E	1.308	2.585	0.506
F	1.226	3	0.409

The estimated Shannon-Wiener Index of species diversity of storks was highest in Zone F (H=1.851). The maximum species diversity represented similar values in five Zones, namely A, B, C, E and F (H_{max}=2). The relative measure of diversity was highest in Zone F (J=0.925) (Table 11).

The species diversity indices of migratory waterfowls were highest in Zone E (H=1.308). The maximum diversity was found in three zones, i.e., A, C and F (H_{max}= 3). The relative measure of diversity was highest in Zone E (J=0.506) (Table 12).

The value of H for waterhens and Common Moorhen *Gallinula chloropus* was highest in Zone A (H=1.453). The maximum diversity was highest in Zone B (H_{max}=2.585). The relative measure of diversity of these birds was maximum in Zone A (J=0.626) (Table 13).

The value of H forwaders was highest in Zone B (H=2.25). The value of H max was highest in three Zones, namely D, E and F (H_{max} = 2.81). The value of J was in Zone B (J=0.87).

The species diversity of gulls was found to be highest in Zone F (H=1.199). The value of H_{max} is highest in Zone F (H_{max}=1.585). Similarly, the value of J was found to be highest in Zone B (J=0.998).

Each winter, migratory and non-migratory waterbirds are counted during the midwinter season in the Rapti, Narayani rivers and marshes and lakes of floodplain areas of CNP. During 2010, a total number of 6072 individuals of nine waterfowl species were recorded followed by 7,550 individuals of 12 species in 2011, 6,884 individuals of 12 species in 2012 and 7,797 individuals of 11 species were recorded in 2013. The 2014 January survey showed an overall increase in the number of waterfowl compared to other years with a total of 9146 individuals. This could be possibly due to the availability of food. The highest observed numbers of Ruddy Shelduck *Tadorna ferruginea* was in 2014, compared to preceding years. During the five-year survey period (2010–2014), only one Greylag Goose *Anser anser* at Laukhani in the Narayani River was observed. In addition, two Common Shelduck *Tadorna tadorna*, one from the Rapti/Lothar confluence, near Sunachuri, on the Rapti River and another from Khoria muhan, the Narayani River near Amaltari were observed with Ruddy Shelduck in the 2012 survey. Interestingly, this species was seen in the same area together with Ruddy Shelduck in 2004 and 2005 (Khadka 2005).

A rare winter visitor Ibisbill *Ibidorhyncha struthersii* was not seen during midwinter survey of 2006, due to the disturbance caused by stone mining around suitable Ibisbill habitat in the Rapti River. In spite of disturbances in the river channel, a single Ibisbill was recorded on 21 December 2005 at Meghauli, Tiger Tops Ghat and another was seen on 05 January 2006 on the Rapti just in front of Kumratha village downstream from Chitwan Jungle Lodge Ghat (Khadka 2005, 2006)

Table 13. Species diversity of waterhens and moorhens

Zones	H	H_{max}	J
A	1.453	2.322	0.626
B	1.305	2.585	0.505
C	0.358	1.585	0.226
D			
E			
F	1.311	2.322	0.565

Table 14. Species diversity of shorebirds and waders

Zones	H	H_{max}	J
A	1.039	2.585	0.402
B	2.25	2.585	0.87
C	2.239	2.585	0.866
D	0.639	2.81	0.227
E	0.531	2.81	0.189
F	0.904	2.81	0.322

Table 15. Species diversity of gulls

Zones	H	H_{max}	J
A	0.954	1	0.954
B	0.998	1	0.998
C	0.592	1	0.592
D	0.881	1	0.881
E	0.863	1	0.862
F	1.199	1.585	0.756

CONCLUSION

Conservation of aquatic birds has been overshadowed by conservation measures carried out for other aquatic and terrestrial flagship species such as the Gharial *Gavialis gangeticus*, Tiger *Panthera tigris* and Greater One-horned Rhinoceros *Rhinoceros unicornis*. Increasing human disturbances through fishing, livestock grazing, gravel/sand/stone extraction, water pollution, poisoning in wetlands and proliferation of alien invasive species arelikely to be the main threats to waterbird conservation. Current conservation measures and monitoring are inadequate for aquatic birds. Active conservation measures in the form of monitoring and stringent protection of riverine habitats including floodplain lakes, marshes and swamps and developing aquatic bird species management protocols are urgently neededfor effective conservation of wetland birds.

Image 2. Great Cormorant in Narayani River

REFERENCES

Acharya, P.M. (2002). The status of wetland environment and threat analysis. A report to UNDP-GEF Conservation and sustainable use of wetlands in Nepal, IUCN Nepal, 114 pp.

Acharya, P.M. & S.L. Rajbhandari (2012). Investigation of population status and habitats of *Lutrogale perspicillata* in Narayani River, Chitwan National Park. A final research report to Rufford Foundation U.K., 50pp.

Baral, H.S. & C. Inskipp (2004). *The State of Nepal's Birds 2004*, Kathmandu. Department of National Parks and Wildlife Conservation, Bird Conservation and IUCN Nepal.

Bhandari, B. (1998). *An inventory of Nepal's Wetlands*. Final report, Kathmandu, Nepal: IUCN Nepal, 329pp.

BCN & DNPWC (in prep). Important Bird and Biodiversity Areas in Nepal.Kathmandu: Bird Conservation Nepal and Department of National Parks and Wildlife Conservation.

BES (2013). *Chitwan Bird Check List.* Bird Education Society, Chitwan, Nepal, 44 pp.

CNP (2013). Chitwan National Park Monthly records - 2013. Chitwan National Park.

CNP (2014). Chitwan National Park Monthly Records - 2014. Chitwan National Park.

CNP (2015). *Status of Wetlands and Mugger Crocodiles in and Around Chitwan National Park*. Chitwan National Park, 152pp.

Dahal. B.R. (2007). Effects of Water-Hyacinth *Eichhornia crassipes* on aquatic birds at Koshi Tappu Wildlife Reserve. *Danphe* 16(1): 64–65.

Grimmett, R., C. Inskipp, T. Inskipp & H.S. Baral (2016). *Birds of Nepal. A Field Guide. Fully Revised Edition.* Christopher Helm, London, 386pp.

IUCN (2004). *A Review of the Status and Threats to Wetlands of Nepal*. IUCN Nepal, Kathmandu, 80pp.

Khadka, B.B. (2005). Midwinter count of waterbirds at Chitwan National Park. *Danphe* 14(3/4): 3–5.

Khadka, B. B. (2006). Bird survey along the Rapti and Narayani Rivers of Chitwan National Park. Unpublished.

Khadka, B.B. (2010). Midwinter waterbirds counts at Chitwan National Park, *Danphe* 19(2/3): 3–8.

Khadka, B.B. (2011). Midwinter waterbirds counts at Chitwan National Park, *Danphe* 21(1): 1–5.

Khadka, B.B. (2012). Midwinter waterbirds counts at Chitwan National Park . *Danphe* 21(1): 3–5.

Khadka, B.B. (2013). Midwinter waterbirdscount in 2012 at Chitwan National Park. *Danphe* 22(2/3): 3–7.

Khadka, B.B. (2014). Bird survey along the Rapti and Narayani Rivers of Chitwan National Park. Unpublished.

Odum, E.P. (1971). *Fundamentals of Ecology*. *3rd Edition.* W.B. Saunders

Company, 574pp.

Rajbhandari, S.L. & P.M. Acharya (2015). Study of investigation of population, habitat and hatching success of *Gavialis gangeticus* in Narayani River of Chitwan National Park. A Final Research Report submitted to Rufford Foundation, U.K., 38pp.

Shah, J.P. (1997). *Koshi Tappu Wetlands: Nepal's Ramsar Site*. IUCN, Bangkok, Thailand, 253pp.

Thapa, I. (2006). Wetland Avifauna of Ponds of Kathmandu Valley: World Wetlands Day, Celebration Report, Kathmandu, Nepal.

Urfi, A.J., M. Sen, A. Kalam & J. Megnathan (2005). Countingbirds in India: methodologies and trends. *Current Science* 89(12): 1997–2003.

WBC (2006). Conservation and Sustainable Use of Beeshazar Lake System: A Five-year Action Plan. Report to The Netherland's committee for IUCN small grant for wetland programme (SWP-IUCN), The Netherlands.

Wei, L.Z. & T. Mundkur (2004). Numbers and distribution of waterbirds and wetlands in the Asia-Pacific region. Results of the Asian Waterbird Census: 1997–2001. Wetlands International, Kuala Lumpur, Malaysia.

Yadav, U.K,, P.K. Jha, D.B. Zobel & M.J. Behan (1987). *A Practical Manual Ecology*. Ratna Book Distributors, 149pp.

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