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Cover: Mugger Crocodile basking on the banks of Savitri River at Mahad in Maharashtra, India. © Utkarsha M. Chavan.

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Population abundance and threats to Black-headed Ibis *Threskiornis melanocephalus* and Red-naped Ibis *Pseudibis papillosa* at study sites in Jhajjar district, Haryana, India

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Abstract: The Black-headed Ibis and Red-naped Ibis are large wading birds of the order Pelecaniformes. This study documents abundance and threats affecting both species at Dighal, Gochhi, and Chhochhi villages located in Jhajjar district, Haryana, India. Field visits were made twice a month at each site from October 2020 to September 2021. Dighal had proportionately the largest populations of both species. Black-headed Ibis were most abundant in wetlands and Red-naped Ibis in agricultural areas. Populations of both species did not vary among seasons. Major threats observed included dumping of solid waste, fishing, growth of weeds, release of untreated sewage, collisions with transmission lines, grazers (e.g., cattle and goats), and stray dogs. The findings of this study suggest that despite having sizable populations near Dighal, both species face major threats and conservation efforts will require monitoring and management of ibis habitat.

Keywords: Dighal wetland, habitat, solid waste, wading birds.

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Author contributions: First author (A) has collected data, analyses the data and give this data a form of rough manuscript. Second author (SR) designed the study along with the first author and give the rough draft a final manuscript form.

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INTRODUCTION

Abundance of a species in an area is largely dependent upon a suitable habitat having all the resources required for its survival and reproduction (Whittaker et al. 1973; Krausman 1999). Ibises were included under the order Pelecaniformes and the family Threskiornithidae of class Aves (IUCN 2016) which includes the average-sized waders having a probing type downwardly curved beak (Hancock et al. 2001; IUCN 2016). Black-headed Ibis *Threskiornis melanocephalus* and Red-naped Ibis *Pseudibis papillosa* are the most widely distributed species of northern and western India (Hancock et al. 2001; Ali & Ripley 2007; BirdLife International 2012).

Black-headed Ibis and Red-naped Ibis were known to utilize the area in and around the shallow water habitat (Hancock et al. 2001), but the most preferred habitat for Black-headed Ibis include wetlands, lagoons, freshwater ponds, riverine lakes, paddies, swamps, marshlands, and salty marshes (Hancock et al. 2001; Chaudhury & Koli 2018); whereas Red-naped Ibis preferred dry zones and agricultural area found near the shallow water land (Thapa & Saund 2012; Chaudhury & Koli 2018). They use these habitats for foraging, nesting, and roosting (Senma & Acharya 2009; Chaudhary 2018). Black-headed Ibis always shows nesting and roosting in colonies of egretries or heronries (Balakrishnan & Thomas 2004; Laughlin et al. 2014; Chaudhury & Koli 2016; Chaudhary 2018). But Red-naped Ibis never shows nesting and roosting in colonies and always tends to form one nest per tree (Senma & Acharya 2009).

Black-headed Ibis usually prefers to feed in seasonal wetlands, as the availability of food is higher than in perennial wetlands (Sundar 2006; Chaudhury & Koli 2018), however, Red-naped Ibis feeds on the insects and crustaceans found in agricultural land and nearby wetland habitat (Hancock et al. 2001). But their habitat were encountering various threats like the discharge of chemicals from industries, deposition of solid waste, washing clothes in nearby wetland areas, spray of pesticides in the agricultural land area, and agricultural land conversion which leads to their population decline (Choudhury 2012). Therefore, some conservation measures should be required to conserve both species.

A very few studies are available regarding the ecology and behavior of both the ibis species in India (Balakrishnan & Thomas 2004; Senma & Acharya 2009; Thapa & Saund 2012; Chaudhury & Koli 2018) and none of them have been conducted in Haryana. So, this present study was conducted at the selected study sites of district Jhajjar, Haryana; based on the following objectives: (1) to census the population of both Black-headed Ibis and Red-naped Ibis in the selected study sites and (2) to evaluate the various threat factors faced by both the Ibis species in their respective study sites. This study will be helpful in the conservation of both the ibises and ultimately provide conservation measures that will prevent the conversion of wetlands or the ponds used by the wading bird species into any sort of urbanization.

MATERIALS AND METHODS

Study area

This present study was conducted at the selected study sites namely Dighal, Gochhi, and Chhochhi villages of district Jhajjar, Haryana. The climatic conditions of the district are subtropical having four different seasons; summer season from May to July; autumn commence in August and ends in late October; winter season approaches from November and last to January and spring season occurs from February to April. District Jhajjar remains arid in summers with an intense hot environment and cold in winters. Approximately, 577 mm of annual rainfall occurs in this region out of which near about 75% occurs in the monsoon period (from late June to August) (Bhatia 2013).

Dighal is located at 28.7694°N & 76.6326°E of Jhajjar district covering 30.57 km^2 geographical areas (Gulati 2001). It constitutes the maximum number of freshwater as well as marshy wetland areas among the three selected study sites, that endows an appropriate habitat for several large number migrant bird species for their environmental needs; ultimately making this area a potential IBA site with a code IN-HR-06 stated by ENVIS (Rahmani et al. 2016). Village Chhochhi is located at 28.7264 °N & 76.6756 °E of district Jhajjar covering only 5.44 km^2 geographical areas (Gulati 2001). The maximum area covered by this village is included under agricultural land with wetland areas acting as homes for a variety of flora and fauna. Village Gochhi lies at 28.7330 °N & 76.5965 °E in Jhajjar district (Figure 1, Image 1). It constitutes a number of wetland areas surrounded by agricultural land areas providing habitat to many species.

Methods

The selected study sites were surveyed twice a month from October 2020 to September 2021. Data regarding the population abundance and threats was collected from sunrise to sunset avoiding the rainy and

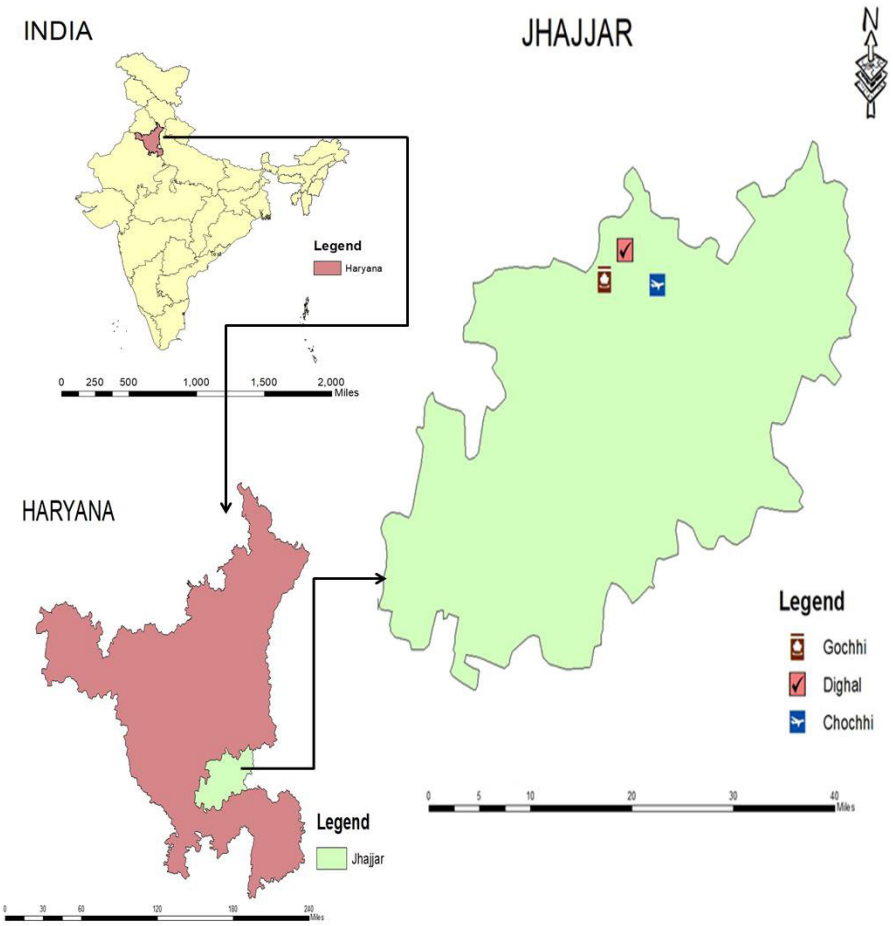

Figure 1. Design of the artificial substrate used for coral transplantation in Palk Bay | a—Top View | b—Front view of the structure | c— Front view of the design.

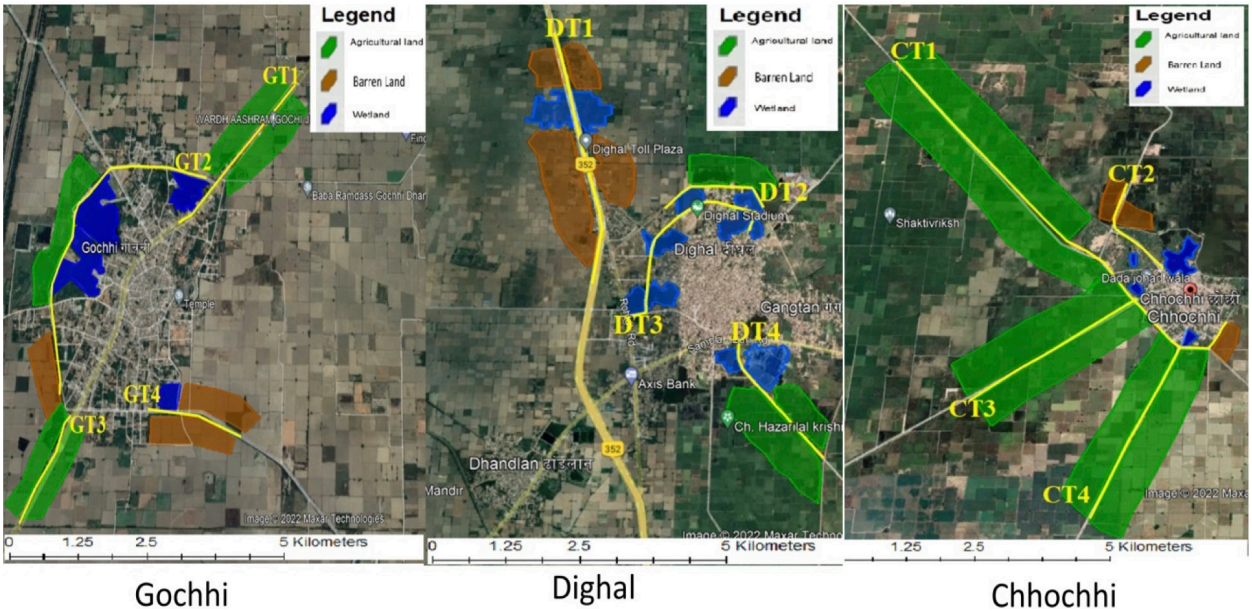

Image 1. Map showing the different study sites surveyed to collect the data for population abundance and threats of Black-headed Ibis and Red-naped Ibis. (Yellow line shows the different transects chosen at selected sites DT1, DT2, DT3 and DT4 transects at village Dighal, GT1, GT2, GT3 and GT4 transects at village Gochhi; whereas CT1, CT2, CT3 and CT4 at village Chhochhi).

foggy days. Line transect method (Gaston 1975) was used to collect the data for the population census. At each study site, four transects of 500 m to 1.5 km were laid to observe the Ibises. On each transect Ibises were observed upto a distance of 250 m on both sides. Nikon 10x50 binoculars were used to scan the Ibises from specific vantage points and Nikon Coolpix P900 point-&-shoot camera were used to capture the photographs. The data regarding the population of both the ibises were represented as mean ± standard error (SE) (Table 1). While the population of both Black-headed Ibis and Red-naped Ibis was compared at different study sites using the One-way analysis of variance (ANOVA). All statistical analysis was done using IBM SPSS 23.

RESULTS

Population

During the entire study period 60 flocks, consisting of 248 individuals (adults and juveniles) of Black-headed Ibis and 83 flocks comprises of 794 individuals (adults and juveniles) of Red-naped Ibis were observed from all three different study sites. Among the three selected study sites, village Dighal holds the major population of both Black-headed Ibis (10.41 ± 1.60) and Red-naped Ibis (28.58 ± 5.57). However, the lowest population of Black-headed Ibis was reported from village Chhochhi (3.50 ± 2.13) and Red-naped Ibis from village Gochhi (10.08 ± 1.78) (Table1). In between different age groups; juvenile Red-naped Ibis does not vary significantly ($P > 0.05$, $F_{2,33} = 2.28$) at distinct study sites. While the number of Black-headed Ibis (adult and juvenile) and Red-naped Ibis (adult) varied significantly among different study sites ($P < 0.05$; $F_{2,33} = 3.96$, $F_{2,33} = 5.53$ and $F_{2,33} = 5.65$; Table 1). Throughout the study period, number of adults was always found to be maximum as compared to juveniles in all study sites.

During this present study population abundance of Black-headed Ibis and Red-naped Ibis does not vary significantly among the seasons ($P > 0.05$, $F_{3,8} = 1.96$, $F_{3,8} = 2.44$) (Table 2). However; the habitat-wise population abundance of both Black-headed Ibis and Red-naped Ibis varies significantly ($P < 0.05$) (Table 3).

Table 1. Population of Black-headed Ibis and Red-naped Ibis censuses from October 2020 to September 2021.

Study site	Black-headed Ibis						Red-naped Ibis					
	N	%	Mean ±Standard error			95% CI (Min– Max)	N	%	Mean ±Standard error			95% CI (Min- Max)
			Adult	Juvenile	Total				Adult	Juvenile	Total	
Dighal	125	50.40%	7.75 ±1.15^{B}	2.66 ±0.66^{B}	10.41 ±1.60^{B}	6.87–13.95	343	43.19%	26.66 ± 5.45^{B}	1.91 ±0.48	28.58 ±5.57^{B}	16.30–40.86
Chhochhi	52	20.96%	3.83 ±0.84^{A}	0.50 ±0.28^{A}	4.33 ±1.07^{A}	1.96–6.70	330	41.56%	26.25 ± 4.32^{B}	1.25 ±0.49	27.50 ±4.44^{B}	17.70–37.29
Gochhi	71	28.68%	5.00 ±1.00^{AB}	0.91 ±0.43^{A}	5.91 ± 1.11^{A}	3.45–8.37	121	15.23%	9.41 ±5.68^{A}	0.66 ±0.22	10.08 ± 1.78^{A}	6.15–14.01
P- value			0.029	0.008	0.001				0.008	0.125	0.006	
F- value (F)			3.96	5.53	5.97				5.65	2.21	5.97	

*N—Total number of observations | CI—Confidence interval. All values are presented in mean ± standard error by one-way ANOVA, significant level at ($P < 0.05$). Different capital letters in superscript among column indicates a significant difference between groups ($P < 0.05$).

Table 2. Seasonal population abundance of Black-headed Ibis and Red-naped Ibis from October 2020 to September 2021.

Seasons	Black-headed Ibis				Red-naped Ibis			
	N	%	Mean ±Standard error	95% CI (Min– Max)	N	%	Mean ±Standard error	95% CI (Min–Max)
Summer	33	13.30%	11.00± 3.21^{A}	-2.83–24.83	116	14.60%	38.66± 12.25^{A}	-14.04–91.38
Autumn	67	27.01%	22.33± 6.33^{A}	-4.91–49.58	163	20.52%	54.33± 14.24^{A}	-6.93–115.60
Winter	92	37.09%	30.66± 7.21^{A}	-0.39–61.72	350	44.08%	116.66± 39.07^{A}	-51.45–284.78
Spring	56	22.58%	18.66± 5.78^{A}	-6.21–43.54	165	20.78 %	55.00± 8.08^{A}	20.22–89.77
P- value	0.198				0.138			
F- value (F)	1.96				2.44			

*N—Total number of observations | CI—Confidence interval. All values are presented in mean ± standard error by one-way ANOVA, significant level at ($P < 0.05$). Different capital letters in superscript among column indicates a significant difference between groups ($P < 0.05$)

Image 2. Solid waste deposition and cattles grazing near Black-headed Ibis. © Anjali

Image 3. Invasion of *Ipomoea aquatica* and stray dogs. © Anjali

Image 4. Risk of collision with transmission lines at village Dighal. © Anjali

Table 3. Habitat wise population abundance of Black-headed Ibis and Red-naped Ibis from October 2020 to September 2021.

Habitat	Black-headed Ibis				Red-naped Ibis			
	N	%	Mean ±Standard error	95 % CI (Min–Max)	N	%	Mean ±Standard error	95 % CI (Min–Max)
Wetland	170	68.54%	56.66± 14.81^{B}	-7.07–120.40	67	8.43%	22.33± 7.53^{A}	-10.08–54.75
Agricultural land	65	26.20%	21.66 ± 5.69^{AB}	-2.84–46.17	545	68.63%	181.66± 30.88^{B}	48.76–314.57
Barren Land	13	5.24%	4.33± 0.88^{A}	0.53–8.12	182	22.92%	60.66± 9.76^{A}	18.63–102.70
P- value	0.018				0.03			
F- value (F)	8.43				18.75			

*N—Total number of observations | CI—Confidence interval. All values are presented in mean ± standard error by one-way ANOVA, significant level at (P <0.05). Different capital letters in superscript among column indicates a significant difference between groups (P <0.05)

Table 4. Types and severity of threats to both Black-headed Ibis and Red-naped Ibis.

	Type of threat	Resulting stress on Black-headed Ibis and Red-naped Ibis	Level of threat
1.	Solid waste deposition	Habitat unsuitable for nesting, feeding and roosting	1
2.	Cattle grazing	Disturbance to Ibis species	3
3.	Feral dogs	Leads to population decline	2
4.	Invasive species	Loss of important habitat for foraging, roosting and nesting	2
5.	Untreated sewage waste	Impacts on habitat quality that leads to reduced food sources	3
6.	Collision with high tension transmission lines	Mortality	2

Scoring for the severity of threats to Black-headed Ibis and Red-naped Ibis (Harris & Mirande 2013). 3—Lesser threat (has been, or has the potential to be, a detrimental factor in some localities or for some populations, but not with a critical impact on the species as a whole) | 2—Significant threat (has been, or has the potential to be, an important though not leading factor in the decline in the population size and/ or restricted to the species range) | 1—Critical threat (has been, or has the potential to be, a major factor in the decline of the population size and/ or restriction of the species range).

Population abundance of Black-headed Ibis was found to be significantly greater in wetland habitat (P <0.05, $F_{2,6}$ = 8.43) as compared to agricultural land and barren land; similarly the population of Red-naped Ibis was also found to be significantly greater in agricultural land area (P <0.05, $F_{2,6}$ = 18.75) as compared to other habitats as shown in Table 3.

Threats

Several threat factors were observed throughout the study period from every study sites; out of which the deposition of solid waste and grazing activities by cattle grazers were the major anthropogenic activities among the study areas (Image 2). These dumping sites are found to be very common at all the study sites majorly found near the wetland habitat. A total number of seven dumping sites were observed from all the study sites out of which four were observed from village Dighal. All along with these anthropogenic activities; some natural threats like stray dogs (3–5 dogs per site) and excessive growth of weeds like *Eichhornia* sp. (Water Hyacinth) and *Ipomoea aquatica* (Water Morning Glory) which reduces their feeding stations seem to be universal at all the respective study sites as shown in Image 3. In context to specific sites, both the Ibises in village Dighal were facing threats like deposition of unprocessed sewage waste and network of high tension transmission lines which lies in approximate 50 m distance from the Ibis habitat can lead to the collision of ibis species (Image 4). Feral dogs were observed to be attacking the Black-headed Ibis in village Dighal. Various threats were classified as lesser, significant and critical in Table 4.

DISCUSSION

In our present study, a total of 248 individuals of Black-headed Ibis and 794 individuals of Red-naped Ibis were reported from all the selected study sites. Out of which maximum number was observed from village Dighal, while the lowest number of Black-headed Ibis from village Chhochhi and Red-naped Ibis from village Gochhi. As abundance depends upon habitat preference (Krausman 1999); this variation in population size among different sites might be because of the difference in the number of wetlands and the agricultural land area surrounding this wetland which act as a most favorable habitat for the Black-headed Ibis as stated by Chaudhury

& Koli (2018) and Red-naped Ibis (Thapa & Saund 2012). Maximum number of Black-headed Ibis and Red-naped Ibis was found in and near-by the shallow water area as they provide feeding, roosting and nesting grounds to waders (Ali 2004; Sundar 2006; Chaudhury & Koli 2018). Similar findings were also observed in this present study among three different habitats, i.e., wetland, agricultural land and barren land respectively; where the population of Black-headed Ibis was found to be highest in wetland habitats (68.54%); while Red-naped Ibis from agricultural land (68.63%). The highest sightings of Black-headed Ibis in village Dighal were observed on either side of the transect (D1) despite of having lots of disturbances due to ongoing traffic on this road. This is probably because of the presence of a very rich supply of food and the surrounding environment providing their roosting habitat. Red-naped Ibis was sighted in higher numbers on either side of the D4 transect having agricultural land and it was observed to be roosting, nesting as well as feeding on some insects.

Chaudhary & Koli (2018) observed that the population of Black-headed Ibis shows a significant increase after the monsoon period when the number of seasonal wetlands increases which increases their feeding guilds (Sundar & Kittur 2013). But in our study, no significant variation in the population size was observed throughout the year among different seasons as well as after the monsoon period. This might be because of the increased water level of the existing wetlands, which is not suitable feeding ground for these shallow water wading birds (Senma & Acharya 2009; Chaudhury & Koli 2018).

Anthropogenic threats in the study areas include the dumping of solid waste, cattle grazing, fishing activities- observed at all sites, however the release of untreated sewage waste observed in village Dighal- which can leads to the destruction of their habitat due to anthropogenic pressure (Prasad et al. 2002) and ultimately can lead to the extinction of the native species found in that area (Godefriod 2001). Dumping of solid waste and growth of weeds like water hyacinth and water morning glory were also observed during the study period, which seems to be a potential threat that eventually leads to the transition of wetlands into a solid land area. The transition of these wetland can diminish the feeding stations of a number wading birds- which could be the ultimate factor for their declining population (Chaudhary 2018). Till now no death records of the Ibises due to collision with transmission lines have been reported, but mortality was observed in many bird species like Sarus Crane and Flamingos due to their collision with transmission lines, so can be considered a major threat (Sundar & Choudhury 2005; Tere & Parasharya 2011; Rameshchandra 2014; Gosai et al. 2016; Kumar & Rana 2021). Koli et al. (2013) noticed predation of eggs and chicks of Black-headed Ibis by House crow and Eagle in Rajasthan, but during this present study, no such observations were made. Although feral dogs were observed to be staring on both the Ibis species at every site, but the killed Black-headed Ibis by the dog was only observed at village Dighal, thus considered as a potential major threat which can lead to population decline. So, to conclude, though village Dighal serves as major habitat for both the Ibises, threats exists for the species. Hence this area requires long-term planning and conservation efforts to conserve the flora and fauna.

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