ISSN 2710-1142(online)
SIS Conservation, 2022, 4, 40-47
RESEARCH ARTICLE

Observations of colonially-nesting Red-naped Ibis *Pseudibis papillosa* at Amla, Gujarat: nest tree preference and breeding success

Anika TERE*

A-17 Janki Duplex, Behind Manjalpur Township No. 2, Darbar Chokdi, Manjalpur, Vadodara-390 011, Gujarat, India
*Corresponding author; e.mails: anikatere@gmail.com

Abstract Colonial breeding is uncommon in Red-naped Ibis *Pseudibis papillosa* with only a few records available from India and Nepal. There are no detailed descriptions of such sites and there is no understanding of conditions under which this species could nest colonially. The species was observed nesting colonially on a regular basis at Amla village of Vadodara district of Gujarat state, India. In this study, I provide detailed documentation of characteristics of nesting sites, a comparison with available trees, document nest location at colonies, and other characteristics of the landscape around the colonial nesting site. The colony was observed for two years (2021 and 2022) with weekly surveys during the nesting period. A total of 12 nests in 2021 and 20 nests in 2022 was recorded. Red-naped Ibis selected two species of trees, *Ficus benghalesis* and *Tamarindus indica*, both of which had large canopies, high diameter, and were protected by local cultures. The ibises nested in a village that had a water source and was surrounded by agricultural fields. Nest success (proportion of nests with at least one chick fledging) was 95% during 2022. Colonially-nesting Red-naped Ibis used cues similar to that used by other large waterbirds in south Asia, such as nesting in a village, preferring few tree species and nesting on the tallest available trees. These conditions occur across the distribution range of this species, and the rarity of colonial breeding in this species is, as yet, inexplicable.

Keywords Colonial nesting, nesting trees, *Pseudibis papillosa*, Red-naped Ibis.

Introduction

The advantage of breeding colonially to waterbirds has remained a topic of great interest among researchers. Food acquisition, predation avoidance, availability of mates and social stimulations are some of the factors that are thought to support colonial breeding in birds (Kopachena 1991; Wagner 1993; Richner and Heeb 1996; Baxter and Fairweather 1998). Habitat selection (selection of a limited number of favourable breeding sites relative to available foraging areas) and sexual selection are considered as important factors, other than food fidelity and reduced predation in evolution of colonial behaviour of birds (Burger 1981; Brown *et al*. 1990; Richner and Heep, 1996; Boulinier and Danchin 1997; Danchin *et al*. 1998; Danchin and Wagner 1999). The distribution and size of waterbird colonies are governed by the availability of suitable nesting sites and habitat composition around nesting sites (Parasharya and Naik 1990; Fasola and Alieri 1992; Kelly *et al*. 1993; Sach *et al*. 2007).

The Red-naped Ibis *Pseudibis papillosa* is widely distributed across the Indian subcontinents (Ali and Ripley 1987). It breeds largely as a solitary nester from March to November varying in different localities and in different years, on trees and artificial structures such as electricity pillion towers, cell phone towers, public lighting poles,

Article history
Received: 12 October 2022,
Received in revised form: 08 November 2022,
Accepted: 09 November 2022,
Published online: 15 November 2022.

and temple flag poles (Whistler and Kinnear 1949; Dodia and Parasharya 1986; Soni 2008; Sangha 2013; Ali *et al*. 2013; Rajesh and Kumar 2019). Colonial breeding is uncommon in Red-naped Ibis with only a few records available from Indian subcontinent. Two pairs nesting on Palmyra palms *Borassus flabellifer* was reported in ICRISAT campus, Patancheru, Medak district, Andhra Pradesh, India (Sangha 2013). A small colony of 3-5 pairs of birds nesting together on the same tree was recorded from Sind, Pakistan (Baker 1935). Hancock *et al*. (1992) recorded two pairs nesting on the same tree in Nepal terai. Existing observations were made over short visits, and it is not known if colonies of Red-naped Ibis are reused over multiple years, similar to the habits of other colonially nesting large waterbirds in the Indian subcontinent. The waterbirds are known to use the same nesting site regularly, for example, Painted Stork *Mycteria leucocephala* in Delhi Zoo (Desai 1971; Meganathan and Urfi 2009, Urfi 2010), Black-necked stork *Ephippiorhynchus asiaticus* in Etawah and Mainpuri districts, Uttar Pradesh (Sundar 2003), Asian Open-bill Stork *Anastomus oscitans* at Nandankanan wildlife sanctuary in Orissa (Mohapatra *et al*. 2019) and many waterbird species at Bhitarkanika mangroves, Orissa, India (Gopi and Pandav 2011).

In 2021, I discovered a site in Vadodara district, Gujarat, in western India where Red-naped Ibis were nesting colonially (Tere 2021). After initial documentation of this phenomenon at this site, I continued visiting the site for another year to document in detail several aspects of the nesting site, nest locations and breeding success to develop an understanding of conditions at colonies in this species. There are no previous detailed descriptions of Red-naped Ibis colonies, and in this study, I provide details gathered over two years.

Study area

Vadodara is a semi-arid district located in central Gujarat in western India (Figure 1). It covers an area of 7,794 km^2 and receives annual precipitation of 83 cm on average (World Weatheronline 2022). Amla village (N 22^0 10' 32.63"; E 73^0 04' 27.20") is located in Padra tehsil of Vadodara district in Gujarat, about 15 km southwest to Vadodara city (see Figure 1). Beside the village, there were two waterbodies, one smaller one (W1) measuring 0.01 Km^2 and a larger one (W2) measuring ~1 Km^2. Agriculture fields and scattered large trees surrounded W1 and W2.

Methods

Site survey

Amla village was surveyed once weekly between 0800 – 1200 h during the active nesting period from April to August, and monthly during the rest of the months in 2021 and 2022. Surveys covered the village on foot to

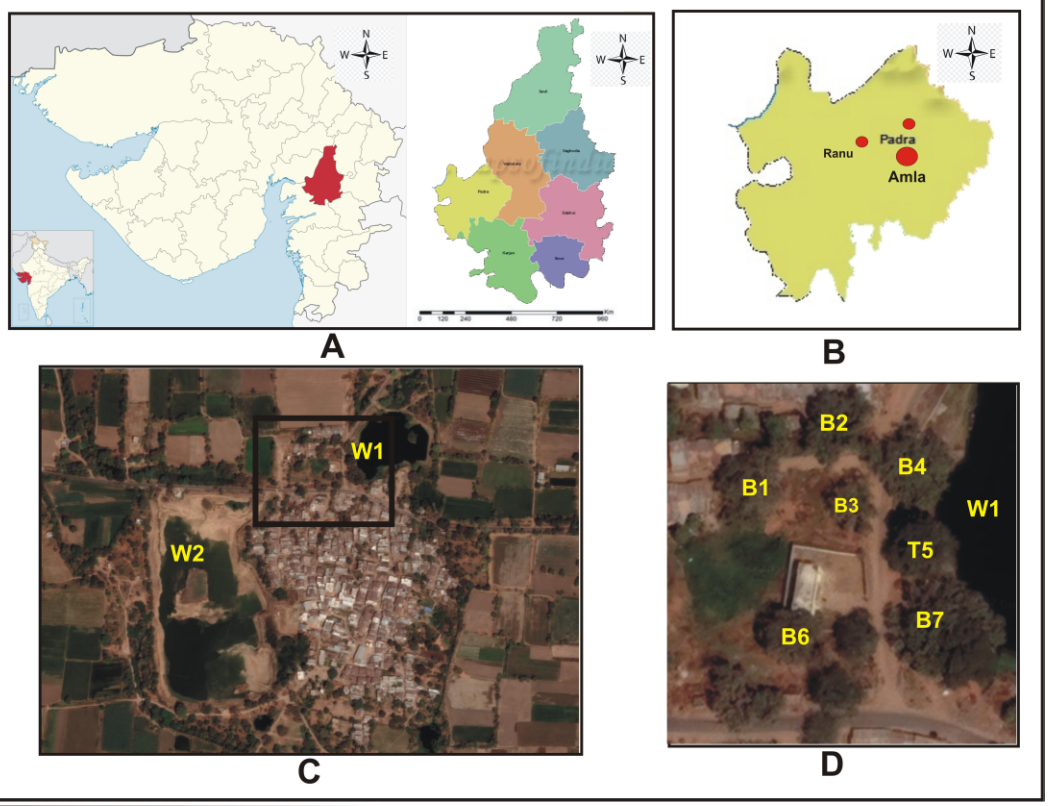

Figure 1. Maps showing the location of Vadodara district in Gujarat state, India (A), the location of Amla village in Padra tehsil of Vadodara district (B), photograph of Amla village showing location of nesting site of Red-naped Ibis (C) and close-up photograph showing location of nesting trees (D; source of photographs: Google Pro Earth). Letters indicate location of nest trees of two species (B - Banyan; T - Tamarind; No. 1 to 7 - numbers given to individual trees with nests). W1 and W2 are the two primary water bodies around Amla.

locate all nests of Red-naped Ibis, and villagers were also questioned to ensure that nests were not missed. If more than one nest occurred on a tree, or on trees with contiguous canopies, it was considered a "colony". In 2021, I also surveyed the area around the village up to 2 km to locate any nesting ibis.

Nests and nesting activity

Total numbers of nests on each tree were counted by walking around nest trees. The heights at which nests were located were measured to the nearest m using a Blume-Leiss altimeter. Distance between neighbouring nests was either estimated visually or by plotting the locations on ground and measured by measuring tape. GPS locations were obtained from the photographs taken using a Sony HX400 camera. Observations on nest initiation, hatching and fledging of chicks was recorded weekly during 2022. Nest success was calculated as the percentage of nests that successfully hatched at least one egg.

Tree morphometry

For each nest tree, species identity, height (to the nearest m using an altimeter), diameter at breast height (DBH; in cm, using a measuring tape), canopy cover (in m^2 using measurements from the trunk in eight cardinal directions), and distance to the nearest neighbouring nesting tree (in m, using a measuring tape, or using Google Earth for trees much further away) were measured. To understand if ibises were preferentially selecting trees for size, the same measurements were taken for all trees ≥ 10 m height found within an area of 0.01 Km^2 that encompassed nest trees. To understand selection of tree species, total numbers of available tree species were recorded by conducting six transects of 500 m each in peripheral area surrounding the nesting site.

Data analyses

To understand whether the selection of trees by ibises does exist for nesting or it occurs randomly, I performed F-tests to compare canopy, DBH and height of (i) trees with nests (TN) and trees without nest (TWN) and (ii) trees with colony and trees with single nests. All tests were performed by using R programme 4.2.1.

Results

Site survey, nests and nesting activities

Colonial nesting of Red-naped Ibises occurred both years. A total of 12 nest in 2021 (two colonies of three and eight nests each) and 20 in 2022 (three separate colonies of three, six and eight nests on each) were observed. In 2021, both colonies were on Banyan trees *Ficus benghalensis*, while in 2022, the Red-naped Ibis added a colony on a Tamarind tree *Tamarindus indicus*. Banyan-1 and Tamarind-5 had maximum nests (Table 1). The nests were built between 8 and 21 m from the ground, with most of the nests located between 14 and 16 m height from the ground. The distance between the adjacent nests on the same tree varied from 1 to 8 m.

Table 1. Details of trees on which colonial and single nesting of Red-naped Ibis was observed during 2021 and 2022 on Banyan (B) and Tamarind (T) trees at Amla, Gujarat. (TH - height of tree in m; No. 1 to 7- numbers of nesting trees).

No.	Trees	Presence of livestock	No. of nests	
			2021	2022
Trees with colonies				
1	B1	√	8	8
2	B2	√	3	3
3	T5	√	0	6
Trees with single nests				
4	B3	√	1	1
5	B4	-	0	1
6	B6	√	0	1
7	B7	√	0	1
Total Nests			**12**	**20**

A pair was observed on Banyan 1 when the site was visited in late February 2022, but nest building was first observed in March. The nesting was asynchronous with the earliest nesting pairs starting nest construction in March 2022 with additional nests started in April and May 2022. Only one pair abandoned the nest, and the rest of the pairs continued with all fledging chicks successfully. Eggs or hatchlings could not be monitored due to height of nests. The chicks were observed in a few nests, but others were blocked by leaves. However, it was possible to observe the fledged young ones as they came out of nests and occupied branches near nest. The nest success was 95 % in 2022. No other solitary or colonial nests of Red-naped Ibis were found within 1 km area around Amla, but a few birds were nesting solitarily in Ranu and Goriyad villages that were further away.

Tree species and morphometry

All the nesting trees were within 0.01 Km^2 area, beside and within human habitation, and located near W1 (Figure 1). Except for one Banyan tree, all other nest trees were used by villagers to tie livestock under the shade (Figure 2). A total of 184 available trees with ≥ 10 m height of 21 species were enumerated (Appendix 1). The ibises preferentially nested on only two tree species –

Figure 2. Photographs showing Banyan tree with nests of Red-naped Ibis on the top and cattle in its shade (A); Banyan tree with nests on the uppermost canopy (B), nest building activity by adult Red-naped Ibis (C) and an adult incubating in the nest (D) at Amla village, Gujarat. (All photographs by Anika Tere.)

Banyan and Tamarind. The mean distance between nest trees was 26 m (± 4 SD). The trees selected for nesting had larger DBH and canopy cover. There was a significant difference between the canopies of TN and TWN (F =11.9, p = 0.0083 < 0.05), however, the canopy of trees with colony and single nests did not differ. Among the TWN, a single Banayan tree had higher DBH and was excluded for F test. Comparison of DBH of rest of TWN with TN showed a significant difference (F = 08.04, p = 0.037 < 0.05). There was no difference in height of TN and TWN and trees with colony and with single nests (Table 2).

Discussion

The Red-naped Ibis nested for two successive years and showed colonial nesting behaviour in both years. Site fidelity of colonial nesting Red-naped Ibis was not known before since past observations were based on short visits in one year (Tere 2021). This colony is located inside a village with nest trees used to shade livestock and is apparently expanding. This is strongly suggestive that Red-naped Ibis benefit from tolerant attitudes of people in rural India. Such tolerance and a high occurrence of colonially-nesting large waterbirds in human-dominated areas such as villages, cities and agricultural areas in south Asia is well known (Sundar *et al*. 2015; Roshnath *et al*. 2019). With this note, we can now add Red-naped Ibis to the list of species that nest successfully under such conditions. Past observations of colonially-nesting ibises were also in urban areas (campus of educational institution; Sangha 2013) and on a tree amid agriculture (Hancock *et al*. 1992).

The number of Red-naped Ibis colonies and single nests increased over the two years of observations. Villagers indicated that the colony has been active for many years, but it is not clear why the growth has increased so much during the study. While the conditions leading to the formation of the colony are not possible to determine, it may be possible to unravel the reasons for colony growth. The pattern of increasing sizes of existing colonies and additional single nests suggests that potential mechanisms at work, singly or in combination, without these being mutually exclusive. These possible mechanisms are: (i) existing colonies are attracting new adult breeders; (ii) adults from nearby areas are coalescing to this site that appears to be safe and leading to relatively high breeding success; and (iii) young birds fledged in previous years are returning with partners (Greenwood and Harvey 1976; Harvey *et al*. 1979; Greenwood and Harvey 1982; Warkentin *et al*. 1991; Fernández-Cruz and Campos 1993; Mckilligan *et al*. 1993;

Table 2. Morphometrics of trees at Amla village, Gujarat. (DH - Distance from house; DW - Distance from Water body-1; TH - Tree height; TC - Tree canopy area; DBH - Diameter at breast height).

No.	Tree species	DH (m)	DW (m)	TH (m)	TC (m^2)	DBH (m)
Trees with Red-naped Ibis nests: colonies						
1	Banyan (B1)	9.85	56.45	17	421.57	6.56
2	Banyan (B2)	8.20	36.55	17	364.3	4.96
3	Tamarind (T5)	9.60	7.34	23	261.01	9.45
Trees with Red-naped Ibis nests: single nests						
4	Banyan (B3)	8.90	26.12	15	160.19	3.63
5	Banyan (B4)	8.65	07.15	15	353.35	6.49
6	Banyan (B6)	8.15	48.63	16	229.05	3.78
7	Banyan (B7)	35.18	6.37	21	748.03	6.48
	Mean	**12.65**	**1.05**	**17.71**	**362.5**	**5.91**
Trees without nests						
1	Tamarind	36.18	6.4	22	235.22	3.2
2	Neem	33.29	33.87	21	160.51	2
3	Neem	11.6	44.88	20	141.68	4
4	Banyan	24.56	69.28	16	279.74	4.58
5	Neem	8.34	55.13	15	120.65	3.80
6	Neem	8.21	110.63	20	195.16	3
7	Neem	3.25	87.51	22	179.79	3
	Mean	**17.91**	**58.24**	**19.43**	**187.54**	**3.37**

Fasola *et al*. 2002; Vergara *et al*. 2006; Mashiko and Toquenaga 2022). Progression of nesting of Red-naped Ibis was asynchronous, which is similar to other large waterbirds in south Asia (Wittenberger and Hunt Jr. 1985; Urfi *et al*., 2007; Suryavanshi and Sundar 2019).

Previous observations on nesting Red-naped Ibises have recorded nests on tree species such as Peepal *F. religiosa*, Neem *Azadirachta indica*, Nilgiri *Eucalyptus* sp., Palmyra palm, Sheeshum *Dalbergia sissoo* and Khejri *Prosopis cineraria* (Baker 1935; Nair and Vyas 2003; Dookia 2004; Soni *et al*. 2010; Sangha 2013; Rajesh and Kumar 2019). In Amla, however, Red-naped Ibises preferentially nested on only Banyan and Tamarind trees despite 19 other tree species being present. They also preferred taller and bigger trees with large canopies, which is identical to choices shown by other colonially nesting waterbirds in south Asia (Gadhavi and Soni 2002; Roshnath and Sinu 2017a; Koju *et al*. 2019). These features of trees are thought to be selected to minimize predation risk and increase shading (Morse 1980).

Amla village is surrounded by agricultural fields and freshwater bodies – both of which are known foraging habitats of Red-naped Ibises (Ameta *et al*. 2022; Asawra *et al*. 2022; Katuwal and Quan 2022). Several studies have suggested that colony locations are tied to proximity to foraging sites that enhance foraging efficiency while provisioning chicks (Tere 2004; Roshnath and Sinu 2017b; Koju *et al*. 2019). It may therefore be that, along with other conditions that waterbirds prefer, such as the absence of disturbance by humans, presence of trees of preferred dimensions, and additionally, potentially predators being dissuaded by the presence of humans, have created the perfect conditions for Red-naped Ibises to nest colonially at Amla. The presence of cattle in vicinity of nesting trees may have additional benefits such as increased insect availability. However, all these conditions appear to exist in many other locations across their distribution range allowing many other waterbird species to nest (Subramanya 1996; Gopi and Pandav 2007; Chaudhury and Koli 2018; Roshnath and Sashikumar 2019; Trivedi and Parasharya 2019; Gohel 2021). It is therefore not clear why colonial nesting of Red-naped Ibis is so rare. Continuing to monitor the apparently growing colony at Amla promises to provide additional understanding and nuances that, at the least, can contribute to understanding breeding biology in the only known location where Red-naped Ibises are displaying high fidelity for nesting colonially.

Acknowledgments

I am grateful to Prof. K. C. Soni and Dr. Manoj Kumar for providing literatures on Black Ibis. I am extremely grateful to Dr. Gopi Sundar for his guidance in improving the manuscript, the figures and tables therein and also for his encouragements to publish my work in SIS Conservation special issue on Red-naped Ibis. I also thank him for providing a few literatures related to this manuscript. I am grateful to Ahba Thakor, Vipra Thakor and Krishna Tendel for helping me in identifying tree species and collecting data on tree morphometrics and frequency. I thank the people of Amla village, especially Mr. Chandrakant Makwana, Mr. Kanubhai and Mr. Ambubhai Zala for their support during the study period and also for providing information about past nesting events. I am thankful to Mr. Sagar Tere for his help in fields during study period. Finally, I thank two anonymous reviewers for suggestions that improved a previous version.

References

Ali, M. S., A. H. S. Rameshkumar and P. R. Arun. 2013. Black Ibis *Pseudibis papillosa* nesting on power transmission line pylons, Gujarat, India. *BirdingASIA* 19: 104-106.

Ali, S. and S. D. Ripley. 1987. C*ompact handbook of the birds of India and Pakistan together with those of Bangladesh, Nepal, Bhutan and Sri Lanka*. 2nd ed. Oxford University Press, Delhi, India.

Ameta, H., V. K. Koli, S. Kittur and K. S. G. Sundar. 2022. Is the Red-naped Ibis *Pseudibis papillosa* a "waterbird"? Distribution, abundance and habitat use in landscapes with two different dominant land use in Udaipur district, Rajasthan. *SIS Conservation* 4: 30-39.

Asawra, K., A. Mitra, K. Mehta, V. K. Koli and K. S. G. Sundar. 2022. Do Red-naped Ibis *Pseudibis papillosa* exhibit scale-dependent habitat use? Effect of wetland extent on seasonal abundance and behaviour of ibis in the semi-arid Dungarpur district, Rajasthan. *SIS Conservation* 4: 60-68.

Baker, E. C. S. 1935. *The nidification of birds of the Indian empire Pandionidae-Podicepidae. Vol IV*. 1st ed. Taylor and Francis, London, United Kingdom.

Baxter, G. S. and P. G. Fairweather. 1998. Does available foraging area, location or colony character control the size of multispecies egrets colonies? *Wildlife Research* 25: 23-32.

Brown, C.R., B. J. Stutchbury and P. D. Walsh. 1990. Choice of colony size in birds. *Trends in Ecology and Evolution* 5: 398-403.

Boulinier, T. and E. Danchin. 1997. The use of conspecifics reproductive success for breeding patch selection in terrestrial migratory species. *Evolutionary Ecology* 11: 505-517.

Burger, J. 1981. A model for the evolution of mixed-species colonies of Ciconiiformes. *Quarterly Review of Biology* 56: 143-167.

Chaudhury, S. and V. K. Koli. 2018. Population status, habitat preference, and nesting characteristics of black-headed ibis *Threskiornis melanocephalus* Latham, 1790 in southern Rajasthan, India. *Journal of Asia-Pacific Biodiversity* 11: 223-228.

Danchin, E., T. Boulinier and M. Massot. 1998. Breeding habitat selection based on conspecific reproductive success: implications for the evolution of coloniality. *Ecology* 79: 2415-2428.

Danchin, E. and R. H. Wagner. 1999. Commodity selection and coloniality: exaggerated traits are produced by processes of choice. Pp. 1290-1292. *In*: Adams, N. J. and R. H. Slotow (eds.) *Proceeding 22 International Ornithological Congress*, Durban. BirdLife South Africa, Johannesburg, South Africa.

Desai, J. H. 1971. Feeding ecology and nesting of Painted Stork *Mycteria leucocephala* at Delhi Zoo. *International Zoo Yearbook* 11: 208-215.

Dodia, J. F. and B. M. Parasharya. 1986. Black Ibis roosting on electric poles. *Newsletter for Birdwatchers* 26 (5 & 6): 16-17.

Dookia, S. 2004. Nesting of Black Ibis *Pseudibis papilliosa* in Thar Desert of Rajasthan. *Zoos' Print* 19(4): 1450.

Fasola, M., H. Hafner, Y. Kayser, R. E. Bennetts and F. Cézilly. 2002. Individual dispersal among colonies of Little Egrets *Egretta garzetta*. *Ibis* 144: 192-199.

Fasola, M. and R. Alieri. 1992. Conservation of heronry sites in North Italian agricultural landscapes. *Biological Conservation* 62: 219-228.

Fernández-Cruz, M. and F. Campos. 1993. The breeding of Grey Herons *Ardea cinerea* in western Spain: the influence of age. *Colonial Waterbirds* 16: 53-58.

Gadhavi, I. R. and V. C. Soni. 2002. Nest and nesting activities of the White Ibis *Threskiornis melanocephalus* Latham in Bhavnagar, Gujarat. *Tigerpaper* 29(2): 22-28.

Gohel, T., T. Chaudhari, P. Dodia, S. Shukla and D. Solanki. 2021. Studies on nesting colonies of heronry birds in Bhavnagar city, Gujarat, India. *Indian Journal of Ecology* 48(1): 91-97.

Gopi, G. V. and B. Pandav. 2007. Observations on breeding biology of three stork species in Bhitarkanika mangroves, India. *Indian Birds* 3(2): 45-50.

Gopi, G. V. and B. Pandav. 2011. Nest space partitioning among colonial nesting waterbirds at Bhitarkarnika mangroves, India. *World Journal of Zoology* 6: 61-62.

Greenwood, P. J. and P. H. Harvey. 1976. The adaptive significance of variation in breeding area fidelity in Black Bird *Turdus merula* L. *Journal of Animal Ecology* 45: 887-898.

Greenwood, P. J. and P. H. Harvey. 1982. The natal and breeding dispersal of birds. *Annual Review of Ecology and Systematics* 13: 1-21.

Hancock, J. A., J. A., Kushlan and M. P. Kahl. 1992. *Storks, Ibises and Spoonbills of the World*. 1st ed. Academic Press, London, United Kingdom.

Harvey, P. H., P. J. Greenwood and C. M. Perrins. 1979. Breeding area fidelity of Great Tit *Parus major*. *Journal of Animal Ecology* 48: 305-313.

Katuwal, H. B. and R. C. Quan. 2022. Status of the Red-

naped Ibis *Pseudibis papillosa* in agricultural landscapes of Nepal. *SIS Conservation* 4: 24-29.

Kelly, J. P., H. M. Pratt and P. L. Greene. 1993. The distribution, reproductive success, and habitat characteristics of heron and Egret breeding colonies in the San Francisco Bay area. *Colonial Waterbirds* 16: 18-27.

Koju, R., B. Maharjan, K. R. Gosai, S. Kittur and K. S. G. Sundar. 2019. Ciconiiformes Nesting on trees in cereal-dominated farmlands: importance of scattered trees for heronries in lowland Nepal. *Waterbirds* 42: 355-453.

Kopachena, J. 1991. Food dispersion, predation and relative advantage of colonial nesting. *Colonial Waterbirds* 14: 7-12.

Mashiko, M. and Y. Toquenaga. 2022. Site Fidelity in lineages of mixed-species heron colonies. *Waterbirds* 41: 355-364.

McKilligan, N. G., D. S. Reimer, D. H. C. Davidson and J. T. Willows. 1993. Survival and seasonal movements of the Cattle Egret in Eastern Australia. *Emu* 93: 79-87.

Meganathan, T. and A. J. Urfi. 2009. Inter-colony Variations in nesting ecology of Painted Stork *Mycteria leucocephala* in the Delhi Zoo (North India). *Waterbirds* 32: 352-356.

Mohapatra, R. K., B. P. Panda, M. K. Panda, S. Purohit, S. P. Parida, K. L. Purohit, J. K. Das and H. S. Upadhyay. 2019. Colonial nesting of Asian openbill storks *Anastomus oscitans* in Nandankanan Wildlife Sanctuary, Odisha. *International Journal of Avian and Wildlife Biology* 4(1): 14-17.

Morse, D. H. 1980. *Behavioural mechanism in ecology*. Harvard University Press, Cambridge, United Kingdom.

Nair, A. and R. Vyas. 2003. Nesting records of Black Ibis *Pseudibis papillosa* in Kota district, Rajasthan. *Zoos' Print Journal* 18(3): 1050.

Parasharya, B. M. and R. M. Naik. 1990. Ciconiiform birds breeding in Bhavnagar City, Gujarat: a study of their nesting and plea for conservation. Pp. 429-445. *In*: Daniel J. C. and J. S. Serraro (eds.) *Conservation in developing countries: Problems and prospects:1990*. Proceedings of Centenary Seminar, Bombay Natural History Society and Oxford University Press, India.

Rajesh and M. Kumar. 2019. Breeding ecology of Black Ibis *Pseudibis papillosa* in agro ecosystem of Punjab, India. *Journal of Experimental Zoology, India* 22(2): 1151-1155.

Richner, H. and P. Heeb. 1996. Communal life: honest signaling and the recruitment center hypothesis. *Behavioral Ecology* 7: 115-118.

Roshnath, R. and P. A. Sinu. 2017a. Nesting tree characteristics of heronry birds of urban ecosystems in peninsular India: implications for habitat management. *Current Zoology* 63: 599-605.

Roshnath, R. and P. A. Sinu. 2017b. Are the heronry birds adapting to urbanization? *Zoo's Print Journal* 32 (12): 27-33.

Roshnath, R., K. Athira and P. A. Sinu. 2019. Does predation pressure drive heronry birds to nest in the urban landscape? *Journal of Asia-Pacific Biodiversity* 12(2): 311-315.

Roshnath, R. and C. Sashikumar. 2019. Conservation challenges of the heronries in Kerala. *Journal of the Bombay Natural History Society* 116: 2019.

Sach, J. L., C. R. Huges, G. L. Nuechterlein and D. Buitron. 2007. Evolution of coloniality in birds: a test of hypotheses with the red-necked Grebe *Podiceps grisegena*. *The Auk* 124: 628-642.

Sangha, H. S. 2013. Nesting of Black Ibis *Pseudibis papillosa* on electricity pylons near Bikaner, Rajasthan. *Indian BIRDS* 8(1): 10-11.

Soni, K. C. 2008. *Study on the population, foraging, roosting and breeding activities of the Black Ibis / Red-naped Ibis* Pseudibis papillosa *inhabiting the arid zone of Rajasthan*. Ph. D. Thesis, Maharshi Dayanand Saraswati University, Ajmer, India.

Soni, K. C., A. N. Sharma and V. C. Soni. 2010. Nesting ecology, interspecific interaction and nesting association of Indian Black Ibis *Pseudibis papillosa* inhabiting the arid zone of Rajasthan. *Our Nature* 8: 12-25.

Subramanya, S. 1996. Distribution, status and conservation of Indian heronries. *Journal of the Bombay Natural History Society* 93(3):459-486.

Sundar, K. S. G. 2003. Notes on breeding biology of Black-necked Storks *Ephippiorhynchus asiaticus* in Etawah and Mainpuri districts, Uttar Pradesh, India. *Forktail* 19:15–20.

Sundar, K. S. G., A. S. Chauhan, S. Kittur and S. Babu. 2015. Wetland loss and waterbird use of wetlands in Palwal district, Haryana, India: the role of agriculture, urbanisation and conversion to fish ponds. *Wetlands* 35: 115-125.

Suryawanshi, K. R. and K. S. G. Sundar. 2019. Breeding ecology of the Painted Stork *Mycteria leucocephala* in a managed urban wetland. *Indian BIRDS* 15(2): 33-37.

Tere, A. 2004. Nesting of Western Reef-Egret *Egretta gularis* in the saltpans of G.H.C.L., Dholera. *Newsletter for Ornithologists* 1(5): 73-74.

Tere, A. 2021. Rare colonial nesting of Black Ibis *Pseudibis papillosa* at Amla, near Vadodara. *Flamingo* Gujarat – Gujarat bird issue 4(2): 11-15.

Trivedi, R. and B. M. Parasharya. 2019. Inland nesting of grey heron Ardea cinerea: An important record for Gujarat state, India. *Journal of Entomology and Zoology* 7(2): 621-624.

Urfi, A. J., T. Meganathan and A. Kalam. 2007. Nesting ecology of the Painted Stork *Mycteria leucocephala* at Sultanpur National Park, Haryana, India. *Forktail* 23: 150-153.

Urfi, A. J. 2010. Using heronry birds to monitor urbanization impacts: a case study of painted stork *Mycteria leucocephala* nesting in the Delhi zoo, India. *AMBIO* 39: 190-193.

Vergara, P., J. I. Aguirre, J. A. Fargallo and J. A. Dávila. 2006. Nest-site fidelity and breeding success in White Stork *Ciconia ciconia*. *Ibis* 148: 672-677.

Wagner, R. H. 1993. The pursuit of extra-pair copulations by

female birds: a new hypothesis of colony formation. *Journal of Theoretical Biology* 163: 333-346.

Warkentin, I. G., P. G. James and L. W. Oliphant. 1991. Influence of site fidelity on mate switching in urban breeding Merlins, *Falco columbarius*. *The Auk* 108: 294-302.

Whistler, H. and B. Kinnear. 1949. *Popular handbook of Indian birds*. 4th ed. Gurney and Jackson, London.

Wittenberger, J. F. and G. L. Hunt Jr. 1985. The adaptive significance of coloniality in birds. *In*: *Avian biology*. D. S. Farner and J. R. King (eds.). San Diego. Academic Press. 8: 1-78.

World Weatheronline. https://www.worldweatheronline.com/ Historical average weather, accessed 27 September 2022.

Appendix 1. Available trees around the sites that colonially-nesting Red-naped Ibis used in Amla village, Gujarat. (Only trees ≥10 m height.)

Sl. no.	Tree species	No.	Sl. no.	Tree species	No.
	Family Moraceae			**Family Caesalpiniaceae**	
1	Banyan *Ficus benghalensis*	6	12	Ashoka *Saraca asoca*	1
2	Peeple *Ficus religiosa*	2	13	Tamarind *Tamarindus indica*	13
3	*Ficus* sp.	1	14	Yellow flame *Peltoforum pterocarpum*	8
	Family Mimosaceae			**Family Fabaceae**	
4	Gorasamli *Pithecellobium dulce*	10	15	Karanjhi *Pongmia pinnala*	9
5	Babul *Acacia nilotica*	15	16	Shirish *Albizia lebbeck*	1
	Family Boraginaceae			**Family Myrtaceae**	
6	Gunda big *Cordia dichotoma*	2	17	Jambu *Syzygium cumini*	9
7	Gundi *Cordera gharaf*	1	18	Nilgiri *Eucalyptus tereticornis*	10
	Family Meliaceae			**Family Ulmaceae**	
8	Neem *Azadirachta indica*	45	19	Jungle cork *Holopteria indigrifolia*	3
	Family Anacardiaceae			**Family Sapotaceae**	
9	Mango *Mangifera indica*	29	20	Mahudo *Madhuca indica*	1
	Family Rutaceae			**Family Combretaceae**	
10	Wood apple *Limonia acidissima*	9	21	Arjun Adad *Terminalia arjuna*	1
	Unidentified species				
11	Unidentified 1	8		**Total**	**184**