

# Hornbill Watch: A citizen science initiative for Indian hornbills

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## Abstract

Hornbills are conspicuous and well-known birds with nine species occurring in India. While several hornbill species have been studied extensively in some parts of India, there is a knowledge gap about their distribution, population size, and adaptations to rapidly changing habitats. Most research and conservation efforts are often focused on single or few species within protected areas. Hornbill Watch (*henceforth*, HW) is an online platform created specifically to record public sightings of hornbills from anywhere in India. The idea is to encourage birders, nature enthusiasts, and photographers to share information on hornbill presence, behaviour, and conservation-related issues. The main objective is to generate baseline information using sight records and enable long-term monitoring of these species by encouraging citizen participation. HW was launched in June 2014, and up to February 2017 had received 938 records from 430 contributors across India, from 26 States and three Union Territories. States from where most sightings were reported were Karnataka, Maharashtra, Tamil Nadu, Assam, and Arunachal Pradesh. Species were reported from both inside (41%), and outside Protected Areas (59%; *henceforth*, PA). Hornbills were reported from 70 PAs. Fifty-one records of nesting were reported for all species from inside and outside PAs, while 27 records of communal roosting were reported for some species. The data obtained thus far has yielded some useful information and insights, and has the potential for enhancing our understanding of current hornbill distribution patterns, and for identifying important sites for conservation/protection.

## Introduction

Hornbills are among the largest birds found in the tropical forests of Asia and Africa. Most Asian species are primarily frugivores and play a critical role as seed dispersers, enabling regeneration of their important food plants and helping maintain the diversity in tropical forests. However, this relatively slow breeding group of birds is extremely vulnerable to threats from anthropogenic pressures like hunting and deforestation (Kinnaird & O'Brien 2007). Most hornbill habitat, particularly in Asia, is under severe pressure from logging and rapidly expanding commercial farms of oil palm *Elaeis guineensis*, tea *Camellia sinensis*, rubber, and coffee *Coffea arabica*. This, along with hunting, has resulted in drastic declines in the geographic ranges of several hornbill species (Trisurat *et al.* 2013) that need to travel over large distances in search of patchily distributed fruit resources (Poonswad & Tsuji 1994; Tifong *et al.* 2007; Naniwadekar *et al.* 2015). Hornbills are also specialist breeders that time their long breeding season with peak availability of fruit resources (Kemp 1995; Kannan & James 1999; Datta & Rawat 2003; Kinnaird & O'Brien 2007). However, there is little information on the extant distribution of various hornbill species and the changes in their distribution over space and time. Given the geographic extent of their distributions, it is difficult to monitor these changes through long-term focused research programs that are often restricted to single or few sites.

Online citizen science initiatives offer an interesting approach that can potentially enable documentation and monitoring of species presence over much wider geographical and temporal scales than can be sustained by focused research projects (Sullivan *et al.* 2014; Bonney *et al.* 2015; Barnard *et al.* 2017). Several of these initiatives are at a global scale, like eBird ([www.ebird.org](http://www.ebird.org)),

which gets five million observations every month. Data from eBird has contributed to more than 100 peer-reviewed publications till date (<https://ebird.org/india/science/publications>). Others are more local, small-scale, with a country/regional focus—sometimes aimed at a single species or particular taxon group such as some recent initiatives in India on sparrows (<http://www.citizensparrow.in>), or on jackals and carnivores outside PAs ([www.carnivore.in](http://www.carnivore.in); Hanssen *et al.* 2014), or focused in understanding long-term changes in bird migration (Quader & Raza 2008; Mendiratta & Quader 2009), and plant phenology (Quader & Mendiratta 2010). Often some citizen science projects are time-bound and short-term such as the sparrow, and the jackal and the carnivore projects, and/or centered on a single question to solve a specific problem (Kummer *et al.* 2016). These initiatives can also aid in large-scale data collection of basic biological or ecological parameters that do not require significant training or specialization. However, data thus gathered often provide insights on large-scale phenological patterns, and bird migration, including the impact of climate change (Quader & Raza 2008; Mendiratta & Quader 2009; Quader & Mendiratta 2010; Mayor *et al.* 2017).

These citizen science platforms are especially relevant for hornbills as several species remain poorly studied and several are vulnerable to extinction, across their ranges, in short time spans. Given that hornbills are conspicuous, large, and easily recognisable, citizen science platforms targeted at hornbills can encourage a wider participation of citizens in documenting information on hornbills and spreading awareness of the vulnerability of these birds to the threats they face, and the importance of their conservation.

## Hornbill Watch (HW): engaging the public

We wanted to create a platform where people from all walks of life could report hornbill sightings from across India along with related information. While we were aware of larger global initiatives like eBird, where hornbill sightings were also being reported, these were usually as part of complete checklists by more experienced or regular birders. We wanted to obtain sightings from a still larger set of people who were not necessarily birders, but who would be able to recognise conspicuous large birds like hornbills. When we were planning, and starting this initiative in 2013–2014, eBird in India was still in its inception stage, and had not been time-tested. Apart from data collection, a dedicated site was also envisioned to act as a public resource for general information on the biology of Asian hornbills, and to disseminate specific information on the nine Indian hornbill species: Great Hornbill *Buceros bicornis*, Rufous-necked Hornbill *Aceros nipalensis*, Wreathed Hornbill *Rhyticeros undulatus*, Narcondam Hornbill *R. narcondami*, Malabar Pied Hornbill *Anthracoceros coronatus*, Oriental Pied Hornbill *A. albostris*, Austen's Brown Hornbill *Anorrhinus austeni*, Malabar Grey Hornbill *Ocyroceros griseus*, and the Indian Grey Hornbill *O. birostris*. Thus, HW ([www.hornbills.in](http://www.hornbills.in)) was started in June 2014 by Nature Conservation Foundation (NCF) and Conservation India (CI) to encourage citizens to participate and share their knowledge of hornbills; to be eventually synthesised and made available for the larger audience at a single source.

Citizens can upload onto this website, sight records and/or images of their hornbill observations from anywhere in the country. The platform has the functionality to select the exact GPS location of the sighting. While HW is open for serious birders to share their hornbill observations, it reaches out to a larger demographic with contributions also coming in from photographers and interested lay people. HW is also a platform where natural history information on hornbills from across India, which is otherwise scattered across diverse fora on social media, is collated. It was established as a long-term initiative to help generate baseline information on the extant distribution of the nine hornbill species, detect and document temporal changes in their geographic distributions, and to use such information to identify important areas for hornbill conservation in the country.

In this paper, we summarise and present the information generated by the HW platform from June 2014 till February 2017 and what we've learnt from this initiative.

## Methods

HW has an interactive web interface that allows a person to report hornbill detections, which could be a call, sighting of a live bird, or a report of a dead/hunted/captive bird from anywhere in India. A contributor enters sighting information and uploads photographs through an online form on the website.

A photograph is not insisted upon, though it is desirable. The website has a format that also encourages users to document additional details of their hornbill sightings that include, bird numbers, any demographic information such as age or sex of the individuals, the behaviours they observed, and the approximate location of their sighting—all without having to register or log in to the website. This makes it a quick, one-step process where sighting details can be uploaded immediately.

This data gets recorded and stored on the site, and its editors (AD, RS & RN) are alerted by e-mail whenever a contribution is uploaded. Subsequently, the data received are reviewed at the back-end. While observations that fall within the known pattern are approved quickly, editors verify the documentation associated with all exceptional records before approving them. If an image has been contributed along with the observation, on approval, it would immediately show up on the Gallery page of the website. Detailed location information is not publicly available on the site. If the information has discrepancies or obvious errors, editors have the right to edit and then approve the sighting. Sometimes, the editors may cross-check the information by writing to the contributor. If the information has errors, which cannot be corrected, we will either quarantine the observation from public view ('REJECT' in our system) or completely remove it from our database (DELETE in our system). Obvious spam is removed from our system. We take

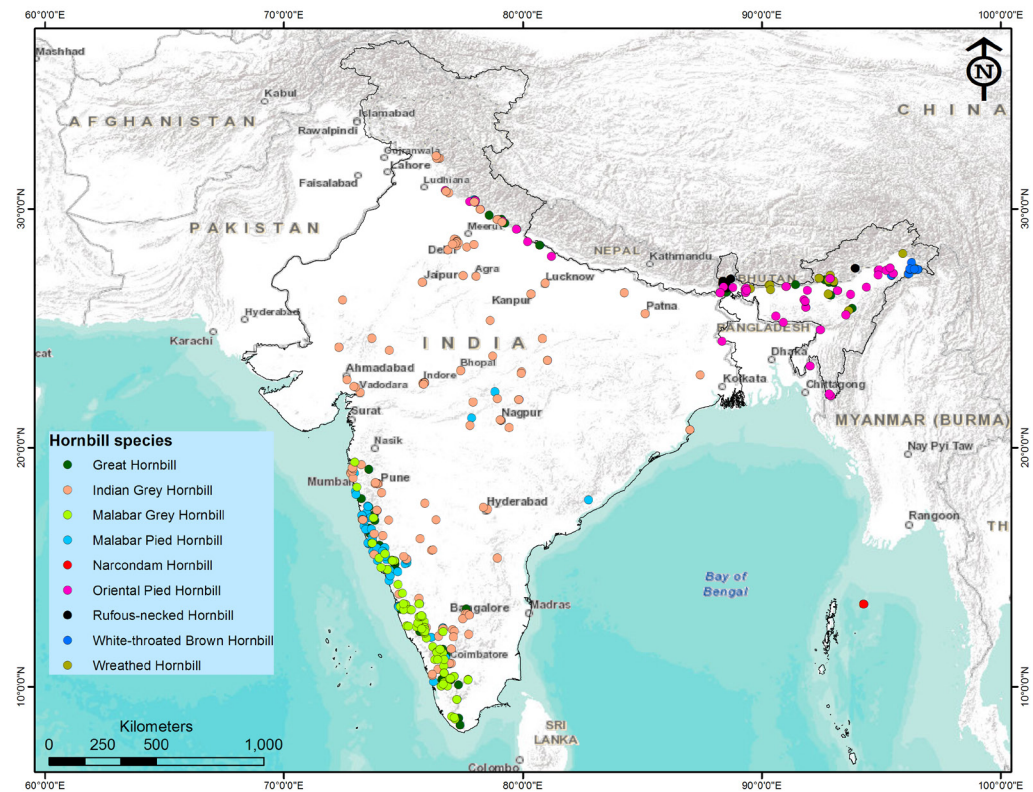


Fig.1 Map of India showing the HW sighting records for all the nine hornbill species.

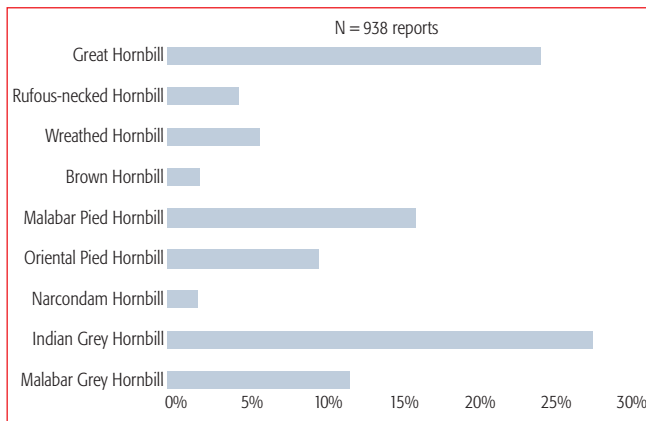


Fig. 2. Percentage reports of the nine different hornbill species from across India between June 2014 and February 2017.

every precaution at the back-end to screen the records from time to time and ensure that our system is not subject to abuse. The data can be downloaded as a comma-separated values (CSV) file, or as an Excel file. Periodic updates are provided on social media through our Facebook page (<https://www.facebook.com/hornbillwatch/>) and the update is uploaded on the website. We also provide a bi-annual, or annual, summary of the data to all contributors, by e-mail, and the report is also uploaded on the website.

Though the website was launched in 2014, contributors can upload their observations from 2000 onwards, which roughly coincides with the time when the Internet discussion groups and digital photography boom happened in the country. This paper contains information from all records submitted between 01 June 2014 and 28 February 2017.

### Results & discussion

Since its launch, HW has received 938 records from 430 people, covering nine Indian hornbill species (Fig. 1), indicating that this platform holds a lot of promise for long-term monitoring of hornbill distribution in India.

That the reports included the Narcondam Hornbill, which is restricted to a six kilometers square remote island, is encouraging. We now have information on Vulnerable and Near Threatened hornbills like the Rufous-necked Hornbill, the Austen’s Brown Hornbill, and the Great Hornbill from several states in north-eastern India.

### Species occurrence reports

The Indian Grey Hornbill was the most reported species (249 records) followed by the Great Hornbill (218) (Fig. 2). There are fewer records of rare species like Austen’s Brown Hornbill (19), and the Narcondam Hornbill (17).

The Indian Grey Hornbill is widespread in India except in north-eastern India, and occupies a diverse array of habitats from savanna to urban landscapes. The Great Hornbill is the other wide-ranging species found in moist deciduous and evergreen forests of the Himalayan foothills and the Western Ghats. A significant proportion of sightings of the Great Hornbill were from outside PAs. It is possible that given the conspicuousness and the charismatic nature of this species, it is more easily observed even if it is locally rare.

Nine hornbill species were reported from 25 of the 29 Indian states, the National Capital Territory of Delhi, and two of the seven Union Territories—Andaman & Nicobar Islands, and Chandigarh (Fig. 3). This is an indication of the wide geographic reportage of hornbills from across the country. Three peninsular Indian states—Karnataka, Maharashtra, and Tamil Nadu—had the highest number of hornbill reports followed by the two north-eastern Indian states of Assam, and Arunachal Pradesh (Fig. 3). Interestingly, these latter two states were among the top five in the number of contributions. It was heartening to obtain records from the states of Nagaland, Mizoram, and Meghalaya where hornbill populations have become less common (Naniwadekar *et al.* 2014). It was encouraging to see hornbill reports from states like Chhattisgarh, and Sikkim, as there is paucity of literature on the presence of hornbills there. One exciting, and unusual, record was of a flock of seven Wreathed Hornbills flying over the Rangapahar Zoo near Dimapur city in Nagaland, which is quite a rare sight. This record (along with a photograph) was reported by the forest department staff at the zoo.

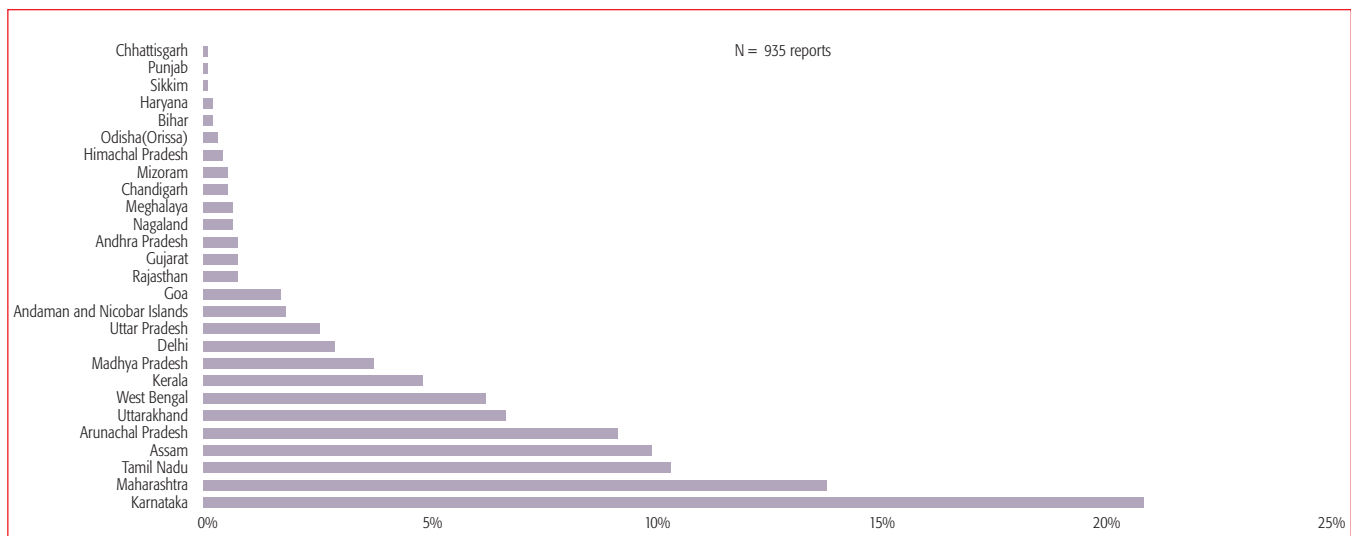


Fig. 3. Percentage of hornbill reports from different states and union territories of India.



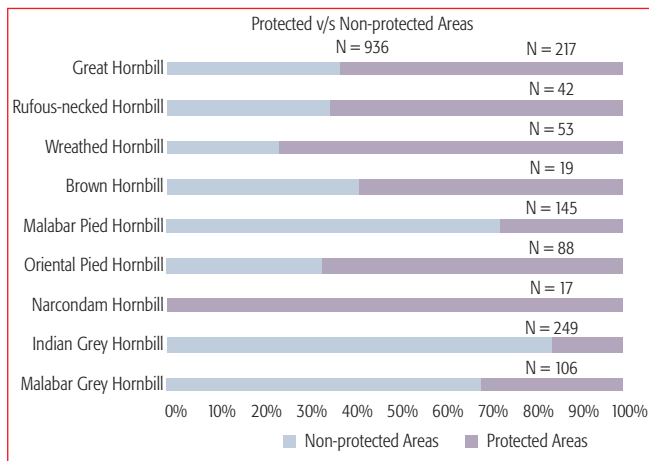


Fig. 4. Relative reports of the nine hornbill species from inside and outside PAs.

The remaining species are restricted either to the Western Ghats in south-western India or to central/eastern India. Within India, the Malabar Pied Hornbill has a disjunct distribution in two regions: central India extending into Andhra Pradesh, eastern India (Bihar and Odisha), and the Western Ghats; we received many records from central India and the Western Ghats, but none from eastern India. The range of the Oriental Pied Hornbill is known to overlap (Grimmett *et al.* 2011) with that of the Malabar Pied Hornbill in Jharkhand and the hill forests of Odisha, and north-eastern Andhra Pradesh. Although we have not obtained any records that show the zone of overlap between the species, on eBird there are records of both species from Mareduhilli in north-eastern Andhra Pradesh and two records each of both species from Odisha, although from different areas in the state. There are, as yet, no records of either species on HW or on eBird from Jharkhand or Bihar but this may be due to a general paucity of data/records from these two states.

There were reports of Oriental Pied Hornbills from Chandigarh and Delhi, which are highly urbanised cities with substantial green spaces. The Chandigarh report is among the westernmost records of this species. The report of the Malabar Pied Hornbill from Andhra Pradesh is interesting as there are relatively few

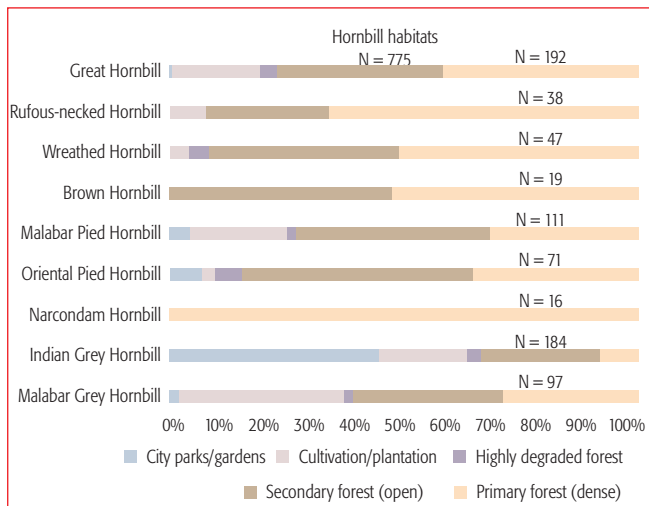


Fig. 5. Percentage reports of the nine hornbill species from five habitat types.

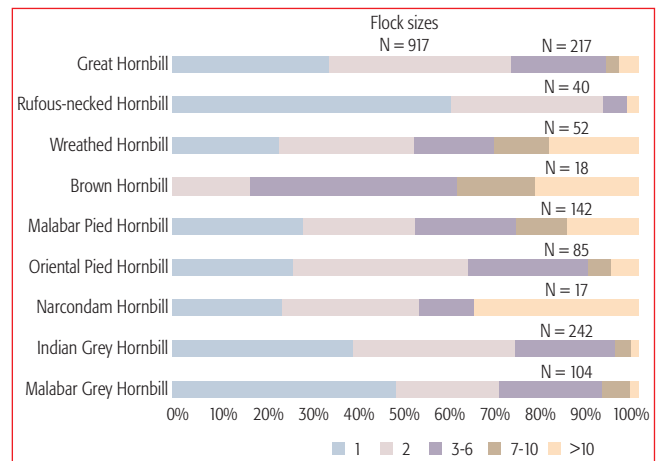


Fig. 6. Percentage reports of each of the nine hornbill species across flock size categories.

records in the literature from the state though potentially it may hold an important population of this species.

Hornbill species were reported from 70 PAs in India. At least one species was reported from 48 PAs. Four hornbill species were reported from only two PAs, Namdapha- and Manas Tiger Reserves. All hornbill species, except the Narcondam Hornbill, were reported from both, inside, and outside PAs (Fig. 4).

More than half the reports of the two smaller hornbill species occurring in peninsular India, and the medium-sized Malabar Pied Hornbill, were from outside PAs. The larger hornbills, and the two medium-sized hornbills (Oriental Pied Hornbill, and Austen's Brown Hornbill) were reported more often from within PAs than outside (Fig. 4).

Most hornbill species were also reported from human-modified landscapes like secondary forests, and rural and urban landscapes (Fig. 5). In fact, most of the sightings (45%) of the Indian Grey Hornbill, the only Asian hornbill that inhabits more open drier habitats, have been from outside PAs, in city parks and gardens (Fig. 5).

More than 50% of the reports of four of the nine hornbill species were from primary forests. However, seven of the nine hornbill species were reported from both secondary forests and

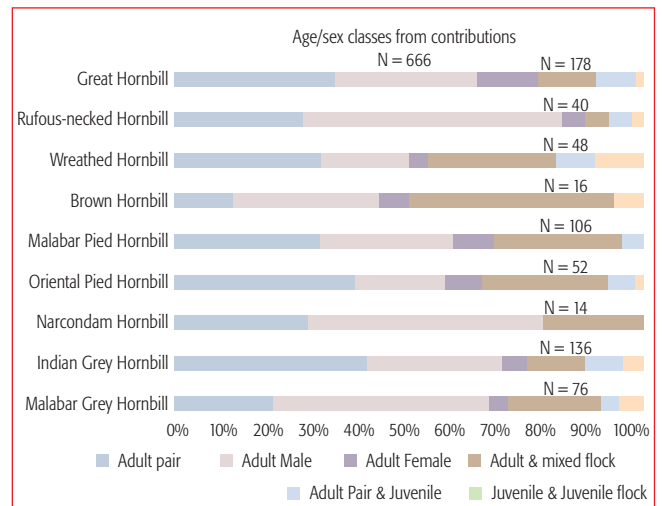


Fig. 7. Percentage reports of various age and sex classes for each of the nine hornbill species (Observations with no age/sex reported were excluded).

plantations/cultivated areas, including large hornbill species like the Great-, Wreathed-, and Rufous-necked Hornbills (Fig. 5), while four species were reported from city parks/gardens.

Almost all the hornbill species were reported either as single birds, or in large flocks of more than ten birds (Fig. 6). Austen's Brown Hornbill was the only one of which a lone bird was never seen. More than 80% of the sightings of this species comprised more than three individuals. More than 45% of the sightings of the Wreathed-, Malabar Pied-, and Narcondam- hornbills were of more than three birds. Sightings of flocks of more than ten birds of these four species were not uncommon (10–30% of sightings across the four species; Fig. 6).

People reported sightings of flocks comprising, adults, single males and females, and juveniles. Sightings of juvenile birds were reported for all but the Narcondam Hornbill (Fig. 7).

### Breeding and roosting

We solicited information on various behaviours such as roosting, breeding, and feeding. HW received feeding records (whether on animal or plant matter), communal roosting inside and outside PAs, and nesting records, although sample sizes were too low to draw conclusions.

We had a total of 36 roosting records of which 22 were from within PAs and 16 from outside, for: the Great-, Indian Grey-, Malabar Pied-, Oriental Pied-, and Wreathed hornbills. In smaller species like the Indian Grey- and Malabar Pied hornbills, roosting was more prevalent outside PAs. In the larger species (Great- and Wreathed) roosting records were mostly from within PAs. The largest reported roost was that of 120 Oriental Pied Hornbills from Rajaji National Park.

Breeding was reported for all the nine hornbill species (total nesting records: 57). Reports of nesting by the Indian Grey-, Malabar Pied- and Austen's Brown hornbills were only from outside PAs, while the number of records for the Rufous-necked-, Oriental Pied-, and Great hornbills came equally from within, and from outside PAs. Surprisingly, nesting records of the rare Austen's Brown Hornbill were reported from outside PAs, while nesting records of the more adaptable Oriental Pied Hornbill were from inside PAs. One record showed a Great Hornbill nesting in a highly degraded habitat (located on a large *Tetrameles nudiflora* tree in the middle of a village close to a resort in Assam where the surrounding forest had disappeared), and five nesting records were from habitat classified as cultivation/plantation, from the Valparai Plateau where tea estates surround forest fragments. While the number of reports are small, these records point to the adaptability of even the large hornbills in areas where they are not hunted.

### Conservation potential

The data obtained from HW is already indicating the potential uses for conservation. Hornbill presence was documented in 70 PAs. For example, PAs like Namdapha, and Manas were identified as areas harbouring four hornbill species. While these two PAs are well-known and better-studied sites, there are many other little known PAs (e.g., Neora Valley National Park in West Bengal, and Barail Wildlife Sanctuary in Assam) in which there has been little research or documentation. HW data therefore enables in identifying PAs that harbour high hornbill diversity in the country. A significant proportion of reports of several hornbill species were from outside PAs. In the long-term,

the HW platform can help identify important areas outside PAs (e.g., Kaiga, and Dandeli town in Karnataka, and Ultapani Reserve Forest in Assam) in terms of the number of sympatric hornbill species, numbers and/or nesting/roosting sites. Several hornbill species are known to roost communally in particular sites over many years, with many roost sites being located outside PAs where they may be more vulnerable to disturbance. The data from HW can identify such roosting sites in particular states (e.g., northern Karnataka, Maharashtra, Assam, and Tamil Nadu) for specific species, and help ensure their protection. Similar information can also be critical for monitoring/protection of nesting sites.

Interestingly, the small Indian Grey Hornbill is the only hornbill that was reported from gardens, parks, and forest patches within cities like Delhi, Mumbai, Pune, Bangalore, Lucknow, and Kanpur among others, highlighting the importance of these green spaces in harboring hornbill populations in urban areas. In Indore, the bird was reported to nest in a cavity in a concrete wall and recorded feeding bread, biscuits and *rotis* (Indian bread) to the female and chicks (Gadikar 2017). Even the two pied hornbills were reported from smaller cities like Pune, Dehradun, Chandigarh, and Guwahati. Surprisingly, the similar-sized Austen's Brown Hornbill was never reported from rural landscapes or plantations; only from primary and secondary forests. Our earlier research has shown that it is vulnerable to anthropogenic perturbations and has significantly lower habitat-use intensity as compared to the similar-sized Oriental Pied Hornbill (Naniwadekar *et al.* 2014). Additionally, HW can potentially identify breeding populations of hornbills at a large spatial scale, especially outside PAs. Given the vulnerability of areas outside PAs to development projects, this information will be crucial in adding to the conservation value of these areas in the future. This data will be made available on request and potentially can be used by environmental lawyers for legal purposes, or by concerned citizens for taking positive action for conservation.

### Limitations of the data

While citizen science is a great tool for data collection, there are limits to how the data generated can be interpreted or used. We can only make limited inferences on hornbill distribution/presence based on the records, since we may not receive information about sightings in some parts of the country for several reasons such as limited network connectivity, lack of awareness about platforms like HW or, lack of interest/time. The lack of records from certain locations does not mean true absence. The data is also not systematically collected and observations submitted are often one-off records from visited sites. The data will also be biased towards areas that are more accessible to people, and frequently visited areas.

### Future of Hornbill Watch

#### Promotion and contributor engagement

After the initial launch, when it was reported in the print media and on social media, the HW platform was not very aggressively promoted. Occasional appeals were made on Facebook through personal pages, the official page, or on other popular Facebook pages where bird images are uploaded frequently, and direct e-mail requests. The periodic updates sent to contributors also resulted in a sporadic spurt in contributions. Social media (Facebook and Instagram) is a good source of

photo-based sightings and behavioural observations, however the information is ephemeral, unless ways can be found to pull in that data and structure it on an ongoing basis. To encourage more participation, HW needs regular and constant promotion on social media sites.

Unlike Facebook or Instagram, where users posting images get immediate appreciation for sharing their images, the gallery on the website does not give people the positive public feedback and connection that may encourage more participation. Keeping contributors engaged through interactive features could be useful to get repeat observations from the same or different locations.

### Handling of sensitive data

One concern is ensuring that the data on HW is not accessible to poachers, or traders of animal parts. While, the data is not accessible from the website, hornbill pictures are displayed in the gallery that names the PAs where the pictures were taken. For hornbill pictures taken outside PAs, only the state name appears in the gallery and the detailed location of the sighting is not available on the website. We have not yet received any data requests but the data will only be shared after verifying the bona fides of such requests. We are constantly vigilant as we are aware that our site is hosting information about several charismatic species that can potentially be threatened by wildlife trade.

### Website security

Websites like ours are launched keeping the larger good of humanity in mind. Hence, aspects like web security, data protection, and data backups are after thoughts. Our website does have basic single-layer protection from external attacks. However, as we grow in size, these issues become paramount and we may get exposed to hackers. We intend to invest more time and energy into this aspect and plug any loopholes that may exist.

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Author contributions: Rohit Naniwadekar (RN) and Aparajita Datta (AD) conceived the idea. Ramki Sreenivasan (RS) and Vikram Hiresavi (VH) developed the HW website. AD, RN and other members of Eastern Himalaya Program, NCF developed content for the website with inputs from RS and VH. Manisha Rao (MR), AD, and RN summarised the data. AD, RN, and MR wrote the manuscript with inputs from RS and VH.

### References

Barnard, P., Altwegg, R., Ebrahim, I., & Underhill, L. G., 2017. Early warning systems for biodiversity in southern Africa – How much can citizen science mitigate imperfect data? *Biological Conservation* 207: 183–188.

Bonney, R., Phillips, T. B., Ballard, H. L., & Enck, J. W., 2015. Can citizen science enhance public understanding of science? *Public Understanding of Science* (PUS) 1–15. DOI: 10.1177/0963662515607406.

Datta, A., & Rawat, G. S., 2003. Foraging patterns of sympatric hornbills during the nonbreeding season in Arunachal Pradesh, northeast India. *Biotropica* 35 (2): 208–218.

Gadikar, A., 2017. Adaptations of the Indian Grey Hornbill *Ocyroceros birostris* in an urban environment. *Indian BIRDS* 13 (6): 167–168.

Grimmett, R., Inskipp, C., & Inskipp, T., 2011. *Birds of the Indian Subcontinent*. 2nd ed. London: Oxford University Press & Christopher Helm. Pp. 1–528.

Hanssen, F., (ed.), Mathur, V. B., (ed.), Athreya, V., Barve, V., Bhardwaj, R., Boumans, L., Cadman, M., Chavan, V., Ghosh, M., Lindgaard, A., Lofthus, Ø., Mehlum, Pandav, B., Punjabi, G. A., F., González Talaván, A., Talukdar, G., Valland, N., & Vang, R., 2014. Capacity building for Intergovernmental Platform for Biodiversity and Ecosystem Services (IPBES). Final report 2014: Indo-Norwegian pilot project on capacity building in biodiversity informatics for enhanced decision making, improved nature conservation and sustainable development. NINA Report 1079. Pp. 1–116.

Kannan, R., & James, D. A., 1999. Fruiting phenology and the conservation of the Great Pied Hornbill (*Buceros bicornis*) in the Western Ghats of Southern India. *Biotropica*. 31 (1): 167–177.

Kemp, A., 1995. *The Hornbills. Bucerotiformes*. Oxford: Oxford University Press. Pp. i–xvi, 1–302.

Kinnaird, M. F., & O'Brien, T. G., 2007. *The ecology & conservation of Asian hornbills. Farmers of the forest*. 1st ed. Chicago & London: The University of Chicago Press. Pp. i–xviii, 1–315.

Kummer, J. A., Bayne, E. M., & Machtans, C. S., 2016. Use of citizen science to identify factors affecting bird–window collision risk at houses. *The Condor* 118: 624–639.

Mayor, S. J., Guralnick, R. P., Tingley, M. W., Otegui, J., Withey, J. C., Elmendorf, S. C., Andrew, M. E., Leyk, S., Pearse, I. S., & Schneider, D. C., 2017. Increasing phenological asynchrony between spring green-up and arrival of migratory birds. *Scientific Reports* 7: 1902. DOI: 10.1038/s41598-017-02045-z.

Mendiratta, U., & Quader, S., 2009. MigrantWatch: changes and results from the second year. *Indian Birds* 4 (4): 122–126 (2008).

Naniwadekar, R., Datta, A., Raghunath, R., Teegalapalli, K., Ghosalkar, M., Borah, B., & Lotha, L. 2014. Hornbill distribution in a biodiversity hotspot: occupancy modeling for hornbills in north-east India. Final report submitted to Assam, Meghalaya, Nagaland, Mizoram and Tripura Forest Departments.

Naniwadekar, R., Mishra, C., & Datta, A., 2015. Fruit resource tracking by hornbills at multiple scales in a tropical forest in India. *Journal of Tropical Ecology* 31 (6): 477–490.

Poonswad, P., & Tsuji, A. 1994. Ranges of males of the Great Hornbill *Buceros bicornis*, Brown Hornbill *Ptilolaemus tickelli* and Wreathed Hornbill *Rhyticeros undulatus* in Khao Yai National Park, Thailand. *Ibis* 136 (1): 79–86.

Quader, S., & Mendiratta, U., 2010. Nature in a changing climate. *Teacher Plus* (May–June): 68–70.

Quader, S., & Raza, R. H., 2008. MigrantWatch: A citizen science programme for the study of bird migration. *Indian BIRDS* 3 (6): 202–209 (2007).

Sullivan, B. L., Aycrigg, J. L., Barry, J. H., Bonney, R. E., Bruns, N., Cooper, C. B., Damoulas, T., Dhondt, A. A., Dietterich, T., Farnsworth, A., Fink D., Fitzpatrick, J. W., Fredericks, T., Gerbracht, J., Gome, C., Hochachka, W. M., Iliff, M. J., Lagoze, C., La Sorte, F. A., Merrifield, M., Morris, W., Phillips, T. B., Reynolds, M., Rodewald, A. D., Rosenberg, K. V., Trautmann, N. M., Wiggins, A., Winkler, D. W., Wong, W.-K., Wood, C. L., Yu, J., & Kelling, S., 2014. The eBird enterprise: an integrated approach to development and application of citizen science. *Biological Conservation* 169: 31–40. DOI: 10.1016/j.biocon.2013.11.003.

Tifong, J., Chimchome, V., Poonswad, P., & Pattanavibool, A., 2007. Home range and habitat use of Rufous-necked Hornbill (*Aceros nipalensis*) by radio tracking in Huai Kha Khaeng Wildlife Sanctuary, Uthai Thani Province. *Thailand Journal of Forestry* 26: 28–39.

Trisurat, Y., Chimchome, V., Pattanavibool, A., Jinamoy, S., Thongaree, S., Kanchanasakha, B., Simcharoen, S., Sribuarod, K., Mahannop, N., & Poonswad, P., 2013. An assessment of the distribution and conservation status of hornbill species in Thailand. *Oryx* 47 (03): 441–450. 📄

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