Characteristics of Narcondam Hornbill *Rhyticeros narcondami* nest trees

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Abstract

The global distribution of the Narcondam Hornbill is restricted to the small Narcondam Island spread over an area of 6.8 sq. km in the Andaman Sea. In this study, we describe the nest site characteristics and abundance of the Narcondam Hornbill nest tree species based on 33 nests (active and potential) that we observed during our study period. We describe nests that we found in 13 tree species including some species which have not been reported in the past literature. The nest trees varied in girth from 103 – 380 cm, and the nest height varied from 4 – 31 m. Abundance of most of the nest tree species was highest in the low (0 – 200 m above mean sea level (ASL)) and mid (200 – 400 m ASL) elevations. The overall density of large trees decreased from lower to higher elevations pointing towards potential reduced nesting opportunities in higher elevations. While more than 57% of cavities were between north-west and north-east facing, 21% of the cavities were south-west and west facing. We have also compiled the list of known Narcondam Hornbill nest tree species based on this and previous studies.

Keywords: Andaman and Nicobar Islands, oceanic island, cavity nesting, *Tetrameles nudiflora*

Introduction

Narcondam Hornbill is a point endemic hornbill species restricted to the Narcondam Island (area: 6.8 sq. km) in the Andaman Sea, India. It has been classified as a Schedule 1 species in the Wildlife Protection Act (1972). The estimated population of the Narcondam Hornbill is 1026 (95% CI: 751 – 1402) birds and the population density of the hornbills is 151 hornbills per sq. km, which is among the highest reported hornbill densities in the world (Naniwadekar *et al*. 2020). Like other hornbills, Narcondam Hornbills nest in secondary tree cavities (Hussain, 1984; Kemp, 1995). No woodpeckers or barbets have been reported from Narcondam Island (Raman *et al*. 2013), so the secondary cavities on trees are likely formed because of branch break-offs may be due to storms and/or wood rot.

Several previous studies have reported the breeding biology of the Narcondam Hornbills

(Hussain, 1984; Sankaran, 2000; Yahya and Zarri, 2002; Vivek and Vijayan, 2003; Manchi, 2017). While most studies report encountering bulk of the nests in the lower elevations (Abdulali, 1974; Sankaran, 2000; Yahya and Zarri, 2002; Manchi, 2017), hornbills have been reported to nest till very close to the Narcondam peak at an elevation of 645 m ASL (Yahya and Zarri, 2002). Height of the nest cavities have been reported to range between 0.6 m to 30 m (Yahya and Zarri, 2002; Manchi, 2017). Girth of nest trees have been reported to range between 132 cm and 1350 cm (Manchi, 2017). Previous studies have reported cavity entrance orientations to be between south-west to south-east directions (Sankaran, 2000; Vivek and Vijayan, 2003; Manchi, 2017).

In this study, we report our observations of Narcondam Hornbill nests. We add new nest tree species hitherto not reported from previous studies. We also report active nesting of hornbills from the third week of January, which has not been reported before. Given that hornbills require large trees for nesting, we also report the densities of large trees (girth ≥ 100 cm and ≥ 270 cm) across the elevation gradient.

Method

Study Area

Narcondam Island is an extinct volcano that erupted less than 7,00,000 years ago and was active till the Holocene (~10,000 years ago) (Bandopadhyay, 2017). It is a remote oceanic island ~ 135 km east of the North Andamans in the middle of the Andaman Sea. The island above the surface of the sea is about 6.8 sq. km in area. The elevation of the Narcondam peak is 710 m ASL. Most of the island has evergreen forest except north-east portion of the island that is dominated by deciduous tree species like *Bombax*, *Gyrocarpus* among others. In 1968, a police outpost was established in the north-eastern part of the otherwise uninhabited island (Raman *et al*. 2013). The camp has barracks and plantations of coconut, arecanut, banana and other fruiting trees around the camp. The estimated size of the disturbed area around the camp was estimated to be around 20 ha in 2010 (Raman *et al*. 2013). While fishing boats have been reported from around the island in the past (Raman *et al*. 2013), we did not see any fishing boats during our time on the island. Cargo ships are regularly seen plying in the waters around the island.

We conducted field work on Narcondam Island to understand the ecological role of Narcondam Hornbill between December 2019 – February 2020. Our stay on the island overlapped with the starting of the breeding season of the Narcondam Hornbill which has been reported to breed between February and May (Sankaran, 2000). During our field work, we found several nests of the Narcondam Hornbill. Hornbill nests were identified based on hornbill presence and activity (nest cleaning, examination or active nesting) near a cavity. Nests were confirmed during revisits to the area unless the nest was in a remote location. Mostly one observer sat at the nest site to minimize disturbance. Nesting was confirmed by observing the nests from a distance (at least 20 m) by suitably hiding in the undergrowth or using camouflage cover. During the revisits, the observer spent several hours to determine hornbill pair activity at the nest. Only when hornbill activity was seen at the nest during the revisit was the nest assumed to be confirmed. Revisits confirmed hornbill activity in all 31 nests and 20 nests had become active (female sealed herself in the nest cavity) by the time we left the island on 10 February 2020. Not all the females had entered and hornbill pairs were observed cleaning the nests till the time we left the island. We measured tree height, nest height, girth at the breast height (1.4 m from the ground), orientation of the cavity entrance and the position of the cavity (main trunk, secondary branch,

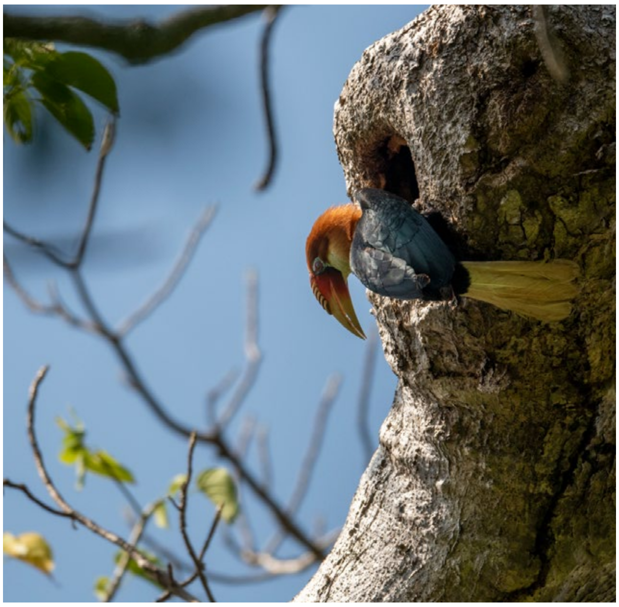

Fig. 1. Adult male Narcondam Hornbill at its nest on *Tetrameles nudiflora*. Photograph by Prasenjeet Yadav.

tertiary branch). Nest and tree height were measured using a range finder unless the tree was on a steep slope and inaccessible, in which case it was visually estimated. Girth was measured using a tape unless it had buttresses (e.g. *Tetrameles nudiflora*). For a buttressed tree, girth of the tree was visually estimated above the buttress. Orientation of the cavity was determined using a field compass or a GPS (Garmin eTrex® 30x). We used the R package 'circular' (Agostinelli & Lund, 2017) to perform the non-parametric Rao's spacing test for determining differences in proportions of nests in the different directions (Rao, 1972). Rao's spacing test was found to perform well for small sample sizes and particularly for investigating the nest cavity orientation in birds (Bergin, 1991). We laid 50 m × 10 m (n = 49) plots across the entire elevation gradient to estimate the abundance and diversity of plants on Narcondam Island. Given the steep gradient as is characteristic of volcanic oceanic islands, it was not possible to randomly lay the plots. However, we ensured that the plots were spread across the different accessible stretches of the island. We recorded all woody plants ≥ 10 cm GBH (girth at breast height). Here we report densities of 15 known Narcondam Hornbill nest tree species across the three elevation zones (low: 0 – 200 m, mid: 200 – 400 and high: 400 – 700 m ASL). We laid 18 plots in the low elevation zone, 14 in the mid and 17 in the high elevation zone. The elevation zones were identified based on topography and vegetation structure and composition. Given that hornbills can nest in other tree species that may have suitable cavities for nesting, we also report overall densities of trees ≥ 100 cm GBH (minimum girth of the observed hornbill nest tree was 103 cm) and ≥ 270 cm GBH (the mean girth of Narcondam Hornbill nest trees based on our data).

Results

We found 33 Narcondam Hornbill nests in 13 tree species (Table 1). Eleven of the 33 nests were in *Tetrameles nudiflora* (see Fig. 1). New records of nest tree species for the Narcondam Hornbill include *Neonauclea gageana*, *Zanthoxylum* sp., *Aphanamixis polystachya*, *Artocarpus lacucha*, *Casearia andamanica*, *Dysoxylum crytobotryum*, *Garuga pinnata* and *Oroxylum indicum* (Table 1). Two *Ficus* species where we found hornbill nests included *Ficus nervosa* and *Ficus glabberima*. The *Oroxylum* nest and one nest in *Aglaia* sp. were at a remote location and we could not revisit the nest. But during the first visit, we had seen a pair at the entrance of both these cavities inspecting and cleaning the cavity. In the *Ficus glabberima* nest, while extensive Narcondam Hornbill activity (cleaning and female entry) was seen in the cavity during two visits (video available on request), no activity was seen on the third visit. All the active Narcondam Hornbill nests were in live trees but for one that was in a dead *Tetrameles nudiflora* tree.

Hornbills started nesting in the third week of January. We found nine active nests of Narcondam Hornbills in last week of January. On 23 January

Table 1. Consolidated checklist of Narcondam Hornbill nest trees and nest tree characteristics (mean and range).

Species	Number of nests	GBH (cm)	Nest height (m)	Tree height (m)
Tetrameles nudiflora+	11	351 (300-380)	22.6 (15-31)	35.4 (30-42)
Aglaia sp.	3	207 (190-235)	12.3 (9-16)	23 (22-25)
*Neonauclea gageana**	3	270 (220-310)	10 (6-14)	24.7 (18-29)
Zanthoxylum sp.*	3	248 (198-293)	13 (8-16)	28 (22-32)
*Aphanamixis polystachya**	2	340 (330-350)	19 (14-24)	22.5 (17-28)
*Artocarpus lacucha**	2	245 (190-300)	10 (8-12)	30 (26-34)
Ficus nervosa	2	260 (220-300)	17.5 (15-20)	33.5 (33-34)
Planchonella longipetiolatum#	2	200 (200-200)	21.5 (18-25)	28 (28-28)
*Casearia andamanica**	1	175	8	21
*Dysoxylum crytobotryum**	1	103	4	16
Ficus glabberima	1	160	29	42
*Garuga pinnata**	1	270	12	30
*Oroxylum indicum**	1	111	6	18
Sterculia rubiginosa	Reported by Hussain (1984)			
Canarium euphyllum	Reported by Sankaran (2000) and Vivek and Vijayan (2003)			
Myristicaceae	Reported by Yahya and Zarri (2002)			
Aglaia hiernii	Reported by Manchi (2017)			
Aglaia andamanica	Reported by Manchi (2017)			
Erythrina indica	Reported by Vivek and Vijayan (2003) and Manchi (2017)			
Dillenia indica	Reported by Manchi (2017)			
Terminalia bialata	Reported by Manchi (2017)			
Pajanelia longifolia	Reported by Manchi (2017)			
Hopea odorata	Reported by Manchi (2017)			

* Species have not been reported as nest tree species prior to this study.
+ Reported as nest tree by Sankaran (2000), Yahya and Zarri (2002), Vivek and Vijayan (2003), Shankar Raman *et al*. (2013), Manchi (2017).
# Reported as nest tree by Hussain (1984). Sankaran (2000), Vivek and Vijayan (2002) and Manchi (2017) have reported hornbill nests in *Ficus* but specific species have not been reported.

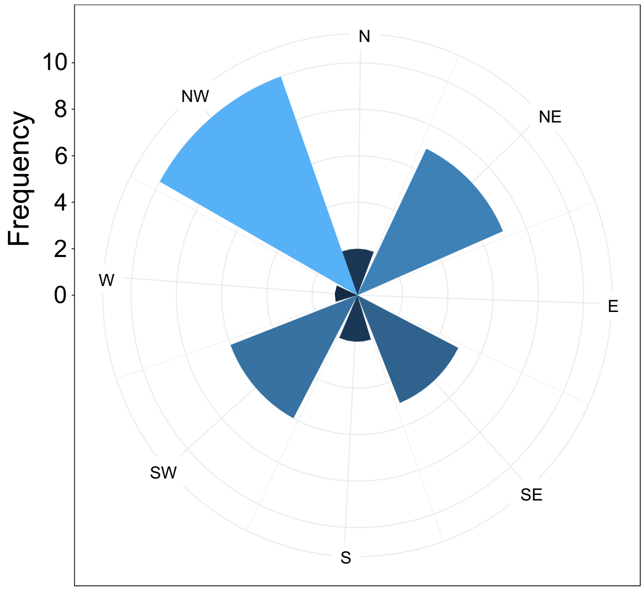

Fig. 2. Circular plot showing frequency of the 33 cavities in different cardinal directions (N – North, E – East, S – South, W – West).

The mean girth of the nest trees was 271 cm (range: 103 – 380 cm). The average nest height was 16.7 m (range: 4 – 31 m). The average tree height was 30 m (range: 16 – 42 m). Species-wise details of nest tree characteristics are outlined in Table 1. Out of the 29 cavities for which the position of the cavity was recorded, 51.7% of the cavities were on the main trunk of the tree, 44.8% of the cavities were in the secondary branch and a single cavity was in the tertiary branch of a *Tetrameles nudiflora* tree. Out of the 33 cavities, 30.3% were north-west facing, 21.2% were north-east facing, 18.2% were south-west facing, 15.2% were south-east facing, 6.1% cavities were north and south facing and a single cavity was west facing (Fig. 2). Rao's spacing test indicated that the orientation of nests was not uniformly distributed in all the directions (U = 283.6, $p < 0.05$). The circular mean of the nest cavity orientation was in the north-west direction.

2020, we found three active nests of Narcondam Hornbills on a single trail between 225 – 300 m ASL. We knew of two of the nests (nest in *Casearia* and *Artocarpus*), the third nest (*Zanthoxylum*) was found on 23 January 2020. The *Artocarpus* nest was partially sealed indicating that the female must have entered at least a day before if not more. Nest cavities entrance of *Casearia* and *Zanthoxylum* were not visible.

The density of most of the tree species that have been recorded as hornbill nest trees was higher in the low and middle elevation zones (Table 2). The mean density of trees with GBH ≥ 100 cm was similar across the low and mid-elevation zones and marginally lesser in the high elevation zone (Table 3). However, large trees (≥ 270 cm GBH) occur in almost eight times higher densities in low elevation zone as compared to the highest elevation zone (Table 3).

Table 2. Densities (per ha) of the nest tree species across the three elevation zones (low: 0-200 m, mid: 200-400 m, high: > 400 m). Zone with highest tree densities are shown in bold.

Species	Density (ha^{-1})low elevation	Density (ha^{-1}) mid-elevation	Density (ha^{-1}) high elevation
Tetrameles nudiflora	2.2 ± 1.5	**4.3 ± 2.3**	0 ± 0
Aglaia sp.	11.1 ± 4	**18.6 ± 6.1**	4.7 ± 2.72
Neonauclea gageana	**7.8 ± 4.9**	4.3 ± 3.1	1.2 ± 1.2
Zanthoxylum sp.	1.1 ± 1.1	**4.3 ± 2.3**	0 ± 0
Aphanamixis polystachya	18.9 ± 6.8	**20 ± 8.2**	14.1 ± 5.1

Species	Density (ha^{-1})low elevation	Density (ha^{-1}) mid-elevation	Density (ha^{-1}) high elevation
Artocarpus lacucha	0 ± 0	**2.9 ± 1.9**	0 ± 0
Ficus nervosa	3.3 ± 2.4	**8.6 ± 4.6**	7.1 ± 2.9
Planchonella longipetiolatum	**17.8 ± 10.1**	1.4 ± 1.4	0 ± 0
Casearia andamanica	0 ± 0	0 ± 0	**5.9 ± 23**
Dysoxylum crytobotryum	**73.3 ± 35.6**	7.1 ± 3.4	1.2 ± 1.2
Ficus glabberima	1.1 ± 1.1	2 ± 1.9	**10.6 ± 2.5**
Garuga pinnata	4.4 ± 3.5	4.3 ± 2.3	**8.2 ± 3**
Oroxylum indicum	**12.2 ± 4.6**	5.7 ± 3.3	5.9 ± 5.9
Sterculia rubiginosa	**5.6 ± 3.9**	0 ± 0	0 ± 0
Canarium euphyllum	**6.7 ± 4**	5.7 ± 2.5	1.2 ± 1.2

Table 3: Density of trees per hectare with girth at breast height (GBH) ≥ 100 cm and ≥ 270 cm. The minimum and average GBH of an active Narcondam Hornbill nest tree was 103 cm and 271 cm, respectively, which prompted us to use these two size classes.

Elevation zone (m ASL)	Mean tree density/ha (SE) (≥ 100 cm GBH)	Mean tree density/ha (SE)(≥ 270 cm GBH)	Number of plots
Low: 0 – 200	128.9 (12.0)	18.9 (5.5)	18
Mid: 200 – 400	134.3 (13.8)	10.0 (2.8)	14
High: 400 – 700	118.8 (14.0)	2.4 (1.6)	17

Discussion

Unlike some of the previous studies (Sankaran 2000; Yahya and Zarri, 2002; Vivek and Vijayan, 2003; Manchi, 2017), this was not a study focussed on the breeding biology of Narcondam Hornbill. However, we provide some new information of this point endemic hornbill species. Narcondam Hornbills have been reported to start nesting in February onwards (Poonswad *et al*. 2013). However, we found active nests of Narcondam Hornbill from around the third week of January. Long-term monitoring data on hornbill nesting revealed that hornbills started nesting early in certain years in the recent past in north-east India and central India (Datta *et al*. unpublished data). This is suspected to be an outcome of climate change. Most of the studies on breeding biology of Narcondam Hornbill have been from February onwards (Hussain, 1984; Sankaran, 2000; Yahya and Zarri, 2002; Manchi, 2017) except Vivek and Vijayan (2002) which has not reported hornbills nesting in January. Based on this study it cannot be ascertained whether hornbills usually start nesting in January or not. This will need corroboration over multiple years. Interestingly, hornbills were reported to not have started nesting in March (Cory, 1902). However, this was based on a single day's visit.

While hornbills have been reported to nest even close to the Narcondam peak (Yahya and Zarri, 2002), previous studies have indicated that hornbill nests are relatively more common in the lower elevations as compared to higher elevations (Sankaran, 2000; Yahya and Zarri, 2002; Vivek and Vijayan, 2003; Manchi, 2017). Most of the hornbill nest trees are abundant in the low and the middle elevation zones. We documented higher density of larger trees in the lower elevations as compared to the higher elevations. This is a likely reason for potentially higher nest densities in lower elevations. While average girth of nest trees is around 270 cm, hornbills were found to nest in trees as small as 103 cm GBH thus highlighting that in spite of fewer opportunities, hornbills could continue to nest in higher elevations. Interestingly, density of hornbill food plants was found to be higher in the higher elevations (Naniwadekar *et al*. 2020). Thus, while there might be limited nesting opportunities in higher elevations, fruit resource availability is unlikely to be a constraining factor. Also, Narcondam Hornbills can be frequently seen flying between the top and the base of the peak, and any variation in fruit availability across the elevation gradient is less likely to affect hornbills because of their vagility. A significant proportion of nests were south-west facing. Given that hornbills nest in relatively dry periods and the chicks are likely to fledge by the onset of the monsoon, cavities oriented in south-west direction are less likely to be affected by rain. Additionally, given the south-west monsoon that brings much of the storms on the island, more cavities are likely to form in the south-west direction. Given the high Narcondam Hornbill densities on the island, it is likely that they might take up sub-optimal cavities like the cavities facing in the south-west direction as nests.

We found additional nest tree species which have hitherto not been reported (Table 1). Suitable cavities in any tree species are likely to be taken over by hornbills as nests. *Tetrameles* is known to be an important hornbill nest tree species (Datta and Rawat, 2004). *Tetrameles* is a softwood, and are usually large, emergent trees. Therefore, *Tetrameles* is more likely to have cavities and are more commonly recorded as a hornbill nest tree. There are few tree species that have been reported as nest tree species in the past, including *Hopea odorata*, *Dillenia indica*, *Pajanelia longifolia* and *Terminalia bialata* (see Table 1) which were not found on the island despite exhaustive floristic sampling (Page *et al*. 2020). *Dillenia indica* has been reported as hornbill food plant (Yahya and Zarri, 2002). This is likely to be an error as *Dillenia indica* is widely found in different hornbill habitats in north-east India but nowhere has it been found to be in the diet of the hornbills (Datta, 2001; Naniwadekar *et al*. 2015). One of the objectives of the study was a systematic plant species inventory of the Narcondam Island that resulted in almost 100 new plant species records for Narcondam Island (Page *et al*. 2020) but the aforementioned four species were not found on the island. These species have also not been reported by Prain (1893) who carried out the first floristic survey of Narcondam Island. Either these tree species are rare and the present survey missed detecting them or they have been misidentified in the past. This needs to be resolved in future studies.

It is indeed remarkable that despite the absence of cavity makers like barbets and woodpeckers, hornbills and other cavity nesting birds like the Alexandrine Parakeet *Psittacula eupatria* and Common Hill Myna *Gracula religiosa* find nesting opportunities on the island. While the Narcondam Hornbill is super abundant, the other two species are not (Naniwadekar *et al*. 2020). Narcondam Hornbills have been observed to chase away the Alexandrine Parakeets from at least two different nest cavities in 2002 (VR pers. obs.). The competition between the three species for the cavities and its outcome on populations of these birds on the island needs to be investigated in the future. Given that the island has hyperabundance of figs and other food plants, the relative rarity particularly of the Common Hill Myna, a frugivore, could be a consequence of limited nesting opportunities (Naniwadekar *et al*. 2020). This also highlights the role of other natural processes (storms and/or wood rot) in cavity generation and they by themselves can create substantial numbers of cavities which potentially contributes to high hornbill densities on the island. In the past, there were reports of tree felling for fuelwood (Sankaran, 2000). However, the police have been provided with gas cylinders and stoves. Given the presence of degraded forests around the barracks (area: ~ 4-5 ha), there is potential for restoration of degraded patches around the police barracks in the near future. Given the island's small size and it being home to the only population of the Narcondam Hornbill, the past conservation interventions of goat removal from the island and drastic reduction in fuel wood use are positive steps towards safe-guarding the hornbill habitat and thereby the hornbills in the long-term.

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Data Availability Statement

Data associated with nest characteristics of the Narcondam Hornbill are available from the Dryad Digital Repository https://doi.org/10.5061/dryad.5mkkwh73p.

References

Abdulali H. 1974. The fauna of Narcondam Island. Part. 1. Birds. *Journal of the Bombay NaturalHistory Society* **71**:496–505.

Agostinelli C and Lund U. 2017. R package 'circular': Circular Statistics (version 0.4-93). URL https://r-forge.r-project.org/projects/circular/

Bandopadhyay PC. 2017. Chapter 12 Inner-arc volcanism: Barren and Narcondam islands. *Geological Society, London, Memoirs* **47**:167–192.

Bergin TM. 1991. A comparison of goodness-of-fit tests for analysis of nest orientation in western kingbirds (*Tyrannus verticalis*). *The Condor* **93**:164-171.

Cory CP. 1902. Some further notes on the Narcondam Hornbill (*Rhyticeros narcondami*). *Journal of the Bombay Natural History Society* **14**:372.

Datta A. 2001. An ecological study of sympatric hornbills and fruiting patterns in a tropical forest in Arunachal Pradesh. PhD Thesis submitted to Saurashtra University, Rajkot, Gujarat, India.

Datta A and Rawat GS. 2004. Nest-site selection and nesting success of three hornbill species in Arunachal Pradesh, north-east India: Great Hornbill *Buceros bicornis*, Wreathed Hornbill *Aceros undulatus* and Oriental Pied Hornbill *Anthracoceros albirostris*. *Bird Conservation International* **14**:S39–S52.

Hussain SA. 1984. Some aspects of the biology and ecology of the Narcondam Hornbill (*Rhyticeros narcondami*). *Journal of the Bombay Natural History Society* **81**:1–18.
Kemp A. 1995. *The Hornbills*. Oxford University Press, Oxford, UK.
Manchi S. 2017. Status, ecology and conservation of Narcondam Hornbill *Aceros narcondami* on the Narcondam Island, India. Salim Ali Centre for Ornithology and Natural History.
Naniwadekar R, Gopal A, Page N, Ghuman S, Ramachandran V and Joshi J. 2020. The critical ecological role of an endemic, large-bodied frugivore on a small tropical island. bioRxiv https://doi.org/10.1101/2020.07.31.229278
Naniwadekar R, Mishra C and Datta A. 2015. Fruit resource tracking by hornbill species at multiple scales in a tropical forest in India. *Journal of Tropical Ecology* **31**:477–490.
Page N, Naniwadekar R, *et al*. 2020. The Narcondam Project. An interim report submitted to the Andaman & Nicobar Forest Department.
Poonswad P, Kemp A and Strange M. 2013. *Hornbills of the World: A Photographic Guide*. Draco Publishing.
Prain D. 1893. On the flora of Narcondam and Barren Island. *Journal of Asiatic Society Bengal* **62**:39–86.
Sankaran R. 2000. Narcondam Hornbill *Aceros narcondami*. In *A study on the ecology, status and conservation perspectives of certain rare endemic avifauna of the Andaman and Nicobar Islands*. Report submitted to Salim Ali Centre for ornithology and natural History, Coimbatore, India (L. Vijayan, R. Sankaran, K. Sivakumar andV. Murugan, Editors). Coimbatore, India, pp. 57–66.
Raman TRS, Mudappa D. *et al.* 2013. An expedition to the Narcondams: observations of the marine and terrestrial fauna including the island-endemic hornbill. *Current Science* **105**:346–360.
Rao, J. S. 1972. Some variants of chi-square for testing uniformity on circle. *Zeitschrift für Wahrscheinlichkeitstheorie und Verwandte Gebiete*. **22**:33–44.
Vivek R and Vijayan VS. 2003. Ecology and conservation of the Narcondam Hornbill *Aceros narcondami* at Narcondam Island Sanctuary, India. Sálim Ali Center for Ornithology & Natural History.
Yahya, SA and Zarri AA. 2002. Status, ecology and behaviour of Narcondam Hornbill (*Aceros narcondami*) in Narcondam Island, Andaman and Nicobar Islands, India. *Journal of the Bombay Natural History Society* **93**:434–445.


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