

An expedition to Narcondam: observations of marine and terrestrial fauna including the island-endemic hornbill

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Oceanic islands, known for their ecologically sensitive ecosystems and endemic species, are of high conservation significance. The volcanic island of Narcondam in the Andaman and Nicobar Islands, Indian Ocean, is a prime example and the only home of the endemic and globally endangered Narcondam Hornbill. Despite its ecological and evolutionary significance, there has been limited biological exploration and research on the island over the last century. Here, we report on a 2010 expedition to Narcondam, presenting results of our rapid survey of island invertebrates, herpetofauna, mammals and birds (especially the endemic hornbill), and marine life in adjoining waters. The survey recorded dense coral growth in the surrounding waters, and identified 17 fish, 2 sea cucumber, 8 reptile, 28 bird, and 2 mammal species and 13 spider and 8 butterfly taxa. Of these, 4 spiders, 3 butterflies and 6 birds identified to species are new records for the island. The Narcondam Hornbill was frequently encountered and we report trail-based estimates of encounter rate and density, which can serve as a baseline for future monitoring. Both despite its isolation and because of it, Narcondam has faced a number of recent and serious conservation threats, including feral goats, poaching, habitat degradation around the police camp, and proposed installations. While efforts have been made by the Government authorities to stave-off various threats, we highlight the need for further scientific research and monitoring, while according primacy to strict protection and conservation.

Keywords: Conservation, coral reefs, endemic species, Narcondam Hornbill, oceanic islands, wildlife protection.

OCEANIC islands often contain sensitive ecosystems and localized and endemic species, and are therefore signifi-

cant from ecological and evolutionary perspectives. Small, isolated populations on oceanic islands are disproportionately vulnerable to demographic and environmental stochasticity, while island size and degree of isolation influence the degree to which plant and animal communities are depauperate or altered in comparison with the mainland regions¹. Among oceanic islands, those of volcanic origin are of particular interest in the study of recolonization and extinction patterns, as in the famous case of Krakatau^{2,3}. Island communities are also sensitive to invasions by introduced species, leading to decline and extinction of native species – an aspect that constitutes a significant global threat to conservation of biological diversity^{4,5}. Documenting and monitoring species on oceanic islands is thus an important part of conservation efforts.

Narcondam deserves such research and conservation attention. Occupying about 6.8 km², it is an extinct volcano thought to have been active 18,000–20,000 years ago⁶. It is unique for the occurrence of the Narcondam Hornbill (*Rhyticeros narcondami*), which is endemic to the island and has the smallest range among the 31 species of Asian hornbills⁷. Narcondam Hornbill is listed as endangered in the *IUCN Red List of Threatened Species*⁸, and protected under Schedule I of India's Wild Life (Protection) Act of 1972 (ref. 9).

There have been few detailed ecological studies on Narcondam because of its remoteness and inaccessibility for much of the year. Existing information on Narcondam comes from studies of the Narcondam Hornbill spanning a few weeks to around four months, and from descriptions of vegetation and other fauna from over three decades ago. Following the earthquake and tsunami of 26 December 2004 and the volcanic eruptions of Barren Island in the Bay of Bengal from the year 2005 onwards, there was renewed concern about the status of Narcondam Island, the endemic hornbill population, and other

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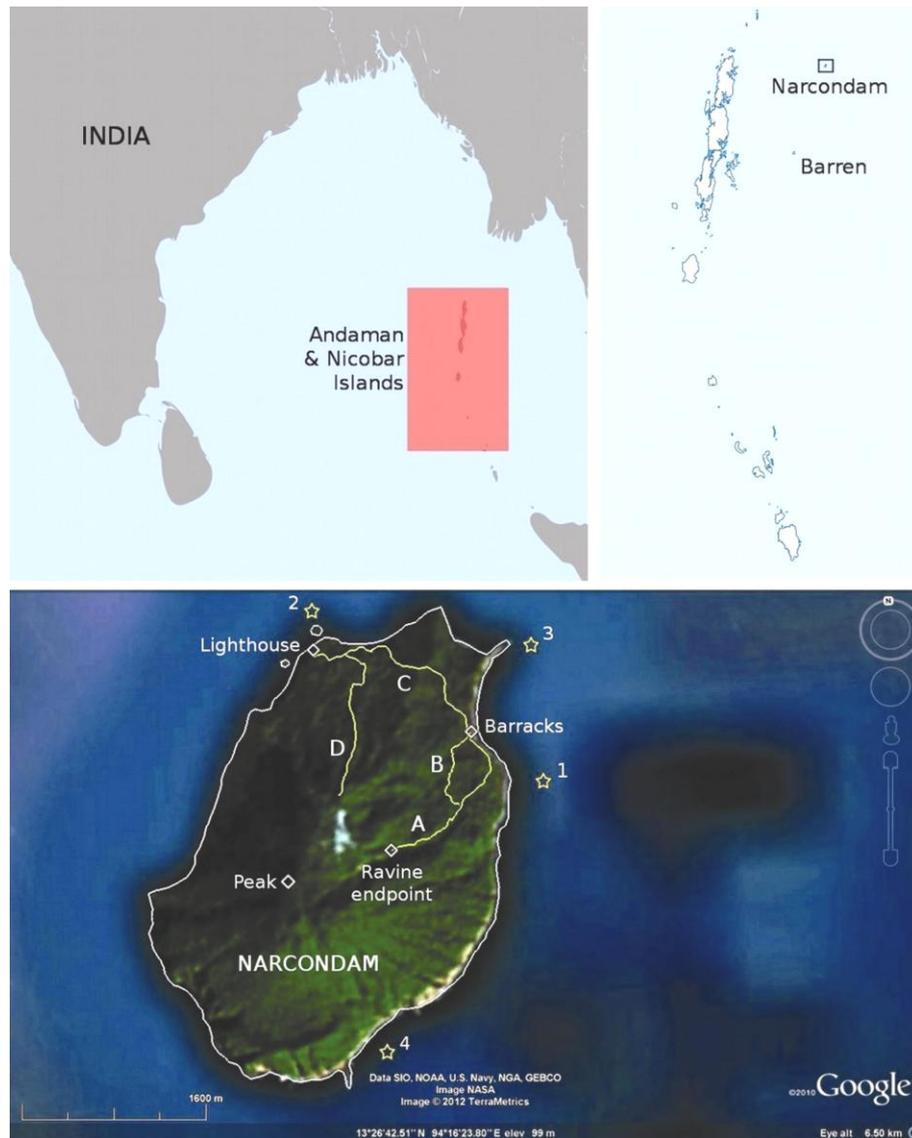


Figure 1. Map showing location of Narcondam Island in the Bay of Bengal (upper panel, island outlines via Wikimedia Commons by NordNordWest), and other features and trails on the island (lower panel, courtesy Google Earth). Trails: A – Ravine trail, B – Hillslope trail, C – Lighthouse trail and D – attempted peak ascent. Numbers 1–4 indicate dive sites (see text for details).

plant and animal taxa. The present expedition was aimed to carry out a rapid survey, with a focus on herpetofauna, spiders, birds and mammals on the island, and marine life in adjoining waters. Although the limited time available precluded detailed studies, we present the survey results, including new species records for the island, to extend the existing documentation of the island's fauna and endemic hornbill, highlight the potential for future research, and outline suggestions for conservation and monitoring.

Study area

Narcondam Island (13°30'N, 94°38'E) is a 6.8 km² oceanic island of volcanic origin, located about 240 km

northeast of Port Blair in the Andaman Islands, Bay of Bengal (Figure 1). Narcondam is located about 135 km to the NNE of Barren Island, a volcano that after historic eruptions between 1787 and 1832, has seen four recent eruptions since 1991, the most recent in 2008–2009 (refs 10 and 11). Geologically, Narcondam features andesite and dacite with evidence for mafic and silicic magma mixing¹², with volcanism reported to have continued into the Holocene¹³. The volcanic cone of Narcondam has a hollow, truncated top rising to 710 m above sea level with two high, unequal shoulders, while its base lies nearly 1000 m below sea level¹³. The densely forested main summit is on the western portion of the island. The island drops steeply on all sides and is fringed with a rocky coast and caverns, with limited access in terms of

suitable landing sites. It was uninhabited until a police outpost was established in 1968 at the only suitable landing site on the northeast of the island. This camp and disturbed surroundings now cover about 20 ha of land, including the barracks and office, coconut and areca groves, banana plantations and vegetable plots¹⁴.

With a humid, tropical, oceanic climate, the island has three main vegetation zones¹⁵: littoral zone along the coastline, moist deciduous/semi-evergreen at lower elevations, and wet evergreen forest on the slopes and higher reaches of the volcano. The littoral vegetation is characterized by species such as *Hibiscus tiliaceus*, *Pandanus*, *Sterculia religiosa*, *Barringtonia speciosa*, *Thespesia populnea*, *Scaevola koenigii* and *Ipomea pes-caprae*. The low-elevation forests have deciduous and evergreen elements including *Terminalia catappa*, *T. bialata*, *Parishia insignis*, *Caryota mitis* palms, *Ficus* sp. and emergent *Tetrameles nudiflora* trees. The evergreen zone includes tree species such as *Dipterocarpus*, *Sideroxylon*, *Ficus* and also deciduous species such as *Bombax*. Osmaston¹⁶, who scaled the peak, notes that the trees towards the summit are stunted, and some montane elements such as *Begonia*, *Aeschynanthus* and *Strobilanthes* appear.

Observations of underwater topography around Narcondam indicated the presence of large boulders and pinnacle-like formations in shallow water areas from 0 to 25 m. Beyond this, coral reef or sand slopes taper off towards deeper water at a 30–60° incline. Sheer, wall-like drop-offs seen around the eastern and northeastern edges of Barren Island seem absent around Narcondam. Depth soundings from the boat corroborated visual observations that Narcondam slopes more gently to the depths of the sea than Barren Island.

Previous surveys and studies

Narcondam has been visited only sporadically by scientists over the past 150 years and usually only for a few hours or days at a time, with the exception of Ravi Sankaran who stayed for over three months to conduct a detailed study of the endemic Narcondam Hornbill¹⁴. Considering visits or surveys with published reports on biological information, the present expedition was the 14th since A. O. Hume's expedition of 1873 that resulted in the discovery¹⁷ of the Narcondam Hornbill (Table 1). Besides these, there have been studies and surveys of the geology and volcanology of Narcondam and Barren Islands over the years^{12,18–23}.

Methods

On 12 April 2010, after securing necessary permissions from the Department of Environment and Forests, Andaman and Nicobar Administration (DoEF-A&N), and Immigration and Harbour Master, Coast Guard, we set

sail from Port Blair on the *Emerald Blue*, a 48-foot sailing sloop owned by Nick Band, based in Phuket, Thailand. We arrived at Narcondam on the following day at about 1030 h and spent three nights and four days until our departure on 16 April.

Field surveys

We explored the coastline and part of the interior, primarily the northeastern third of the island, observing and photographing the fauna and landscapes both above and below water. The survey team concentrated its activities in the vicinity of the police barracks, because of the difficulty of landing on other parts of the island. Several trails made by police and other parties (such as the lighthouse maintenance team) were utilized to access interior areas. An attempt was made to climb the summit, but the team only reached an altitude of 420 m asl and had to turn back because of lack of daylight hours. The dry streambed (only known water source on the island) and major trails were used as transects for hornbill surveys and to look for spoor and for searching under logs, rocks and inside dense thickets. The weather during the survey was hot and humid. Lack of rain and the prevailing hot summer weather may have been sub-optimal, particularly for observations of herpetofauna and jumping spiders.

Marine observations were made over four dives, one on the afternoon of 13 April, two on 15 April and one on the morning of 16 April. Of these dives, the first was on the eastern side slightly south of the police camp beach, the second was on the northern side just off what is commonly called Pigeon Hill, the third was on the northeastern tip of the island, about 200 m north of the police camp beach. The last dive was in a little bay on the southern side of Narcondam (Figure 1). With the new moon falling on 14 April, we had a tidal displacement of 1.6 and 2.0 m for the duration of our stay. Despite this, we had good visibility from the boat and underwater visibility ranging from 15 to 25 m. Opportunistic snorkelling surveys were also made around the boat and up to the reef on the northern tip of the island. Available field guides and taxonomic works were used to identify various taxa^{24–31}.

Hornbill surveys, encounter rate and density

We carried out line transect surveys for hornbills along three non-random, accessible trails (Figure 1) in the vicinity of the police barracks: ravine trail (1.35 km, from the barracks to the water source up the ravine), hillslope trail (1.25 km, behind barracks upslope towards ravine), and lighthouse trail (2.0 km, barracks to the new lighthouse commissioned in 1983). The ravine trail was walked twice, once on 13 April 2010 around noon, and once on 14 April 2010 between 1558 and 1705 h. The

Table 1. Details of biological visits and surveys to Narcondam Island (1873–2010)

Surveyors and source (ref. no.)	Date/year	Details
A. O. Hume ¹⁷	March 1873	Surveyed Andaman and Nicobar Islands and discovered Narcondam Hornbill
D. Prain ^{15,43}	April 1891	Surveyed flora and fauna of Narcondam, described vegetation, noted numbers and tameness of water monitors and hornbills; notes goats have been landed more than once on Barren and Narcondam; notes 18 species of birds, one land snake, water monitor, skinks, [sea] turtles and some invertebrates.
J. H. St. John ⁵⁹	1898	Brief visit, notes 'swarms' of water monitors and hornbills, both not very shy.
C. P. Cory ⁶⁰	22 March 1901	Visited to observe Narcondam Hornbill and secure more skins; notes nesting has not begun and describes plumage and bare parts.
B. B. Osmaston and C. Gilbert Rogers ¹⁶	1–6 October (1904?)	Circumnavigated the island in 19-ft canvas canoe, ascended peak, discovered water source in northeast part (still used); recorded 17 bird species, including seven 'seasonal visitors', two species of fruit bats, rats, water monitors, skinks and a snake.
Robert Grubh and Rex Pimento ⁴⁷	23 April 1969	Eight hours spent on island, recorded ten bird species, water monitors, rats, two kinds of skinks.
Robert Grubh, Humayun and Akbar Abdulali ⁴⁷	29–30 April 1970	Spent an evening and a few hours early morning, observed hornbills and other birds, recorded two species of skinks, two of snakes, rats and fruit bat.
S. A. Hussain and N. J. George ^{44,61}	16 March–14 April 1972	Collected 48 bird specimens (five new species records for Narcondam), some mammals, and reptiles; publication compiled earlier observations; Hussain brought back a pair of adults and two chicks, adult male died en route and female escaped, but the chicks were raised at the Hornbill House in Bombay for six years; ecology and breeding biology studied by Hussain.
S. A. Hussain ⁵⁴	February/March 1991	Notes proliferation of goats and extensive degradation around police camp over 1 km ² area; caution on spread of invasive species such as <i>Eupatorium</i> .
Ravi Sankaran ¹⁴	26 February–2 June 1998	Studied food and breeding of Narcondam Hornbill; estimated population of between 330 and 360 birds; provided targeted recommendations for conservation, including removal of goats, prohibition of hunting, and replacement of fuelwood from tree-cutting by LPG for police camp.
H. S. A. Yahya and A. A. Zarri ⁴⁹	9 and 30 March 2000	Studied nesting, flock composition, and general behaviour; estimated 72–83 hornbills/km ² from unspecified transects extrapolated to total island giving a population of over 430 birds.
R. Vivek ^{62,63}	January–March 2003	Studied roosting and breeding habitat and diet of hornbill, estimated around 365 birds on island from transect survey.
S. Pande and seven others ⁴⁶	18 January 2007	Spent 5 h on island and recorded seven bird species; counted over 100 hornbills; reported monitor lizard hunting for the pot in police camp.
Present study	13–16 April 2010	Results reported here.

hillslope trail was surveyed only on 16 April 2010 (0607 h–0714 h). The lighthouse trail was also surveyed twice, first on 14 April 2010 (0725–1020 h, including half-hour break) and again on 16 April 2010 (0605–0720 h). One to three observers walked these trails together; however, in each case only one observer recorded hornbill observations. We thus surveyed a total length of 7.95 km along these three trails. We also walked on a fourth trail branching from the lighthouse trail towards the peak (Figure 1), but because of the time of day and the steepness of ascent this was not surveyed as a transect.

All hornbills detected by sight, or call, or flying under the canopy (or less than 5 m above the canopy) were categorized into the following perpendicular distance

(from the survey line) intervals in metres: 0–10, 10–20, 20–30, 30–50, 50–75, 75–100, 100–150, 150–200 and >200 m. Distances were estimated visually to each detected cluster (single individual, pair, or flock moving or foraging together). Wherever possible, the number of hornbills in each cluster and the sex of each individual were noted. Of a total of 55 detections along the trails, only 2 were estimated to be beyond 150 m and these were omitted (data truncated at 150 m) for encounter rate and density estimation analysis.

We emphasize that due to non-random placement of survey trails and limitations of logistics, estimates presented here for Narcondam Hornbill should not be extrapolated to the whole island. It is provided purely for the purpose of monitoring in the vicinity of the police

barracks in this particular season as most short-duration surveys will frequently be able to cover only this area on the island. We used the number of detections along each trail to estimate encounter rate as the number of detections per km. We estimated population densities using distance sampling techniques as implemented in the DISTANCE computer program^{32,33} (version 6.0 release 2). We also estimated flock or cluster density. Since flocks could not be fully counted in many cases for visual detections (and all aural detections), we used estimated average flock (cluster) size and its standard error (SE) from data within and outside of the surveyed trails where complete counts of individuals were obtained. We multiplied the average flock size (F) by the average cluster density (C) to obtain individual hornbill density (D). Standard error of individual density (seD) was calculated using standard errors of cluster density (seC) and cluster size (seF) using Goodman's³⁴ formula: $(seD)^2 = C^2(seF)^2 + F^2(seC)^2 - (seC)^2(seF)^2$. Different models of detection probability (half-normal, uniform and hazard rate) with cosine and simple polynomial adjustment terms were examined, and standard model selection procedures in DISTANCE were used to select the best model.

Results

Marine life

Coral growth was common on rock substrate, and prolific and dense in the northeast (dive 3) and southern (dive 4) locations. The reefs included a mixture of commonly observed hard and soft coral and sponges. Hard coral distribution appeared higher at depths of 5–25 m, while soft coral (especially fan and whip coral) was more easily observed along deeper ridges (20–50 m) that were prone to stronger currents. Barrel sponges *Xestospongia* sp. appeared prolific in the reefs and many large, healthy individuals were observed between 12 and 50 m depth, sometimes with large fan corals (order Scleractinia) alongside. Most fan corals were observed on dive 3, in a site evidently prone to strong currents. Interestingly, the common association of feather stars (class Crinoidea) clinging to the edges of fan corals was not as easily observed around Narcondam as in other parts of the Andaman Islands. Whip coral *Leptogorgia* sp. colonies were observed at the deeper (35–50 m) edges of the reef, where the rock substrate gave way to sand. Large whip coral colonies were noted on dives 2 and 3, indicating strong currents during the tidal shift.

Aside from a large school of Blue-fin Trevally *Caranx malampygus* on dive 1, schooling or predatory species like barracuda, tuna or sharks were not noticed, while a manta ray was spotted from the boat in the vicinity of dive 4. Whitespotted Garden Eels *Gorgasia maculata* were plentiful in the approximately 2 ha sandy substrate (at depth of 10–15 m), where the boat was anchored.

Smaller reef fish like *Anthias* and damselfish appeared abundant. Reef fishes recorded while snorkelling around the anchorage and in the reef on the northern tip of the bay included Bigeye Trevally *Caranx sexfasciatus*, Bluelined Snapper *Lutjanus kasmira*, Oriental Sweetlips *Plectorhinchus vittatus*, Longfin Batfish *Platax teira*, Saddleback Butterflyfish *Chaetodon falcula*, Threadfin Butterflyfish *C. auriga*, Collared Butterflyfish *C. collare*, Meyer's Butterflyfish *C. meyeri*, Emperor Angelfish *Pomacanthus imperator*, Indo-Pacific Sergeant *Abudefduf vaigiensis*, Ember (Redlip) Parrotfish *Scarus rubroviolaceus*, Great Barracuda *Sphyrna barracuda*, Powderblue Surgeonfish *Acanthurus leucosternon*, Clown Triggerfish *Balistoides conspicillum*, Stellate (Star) Puffer *Arothron stellatus* and Yellowback Fusilier *Caesiotes*. Two species of sea cucumbers, Worm Sea Cucumber *Synapta maculata* and *Stichopus chloronotus* were also recorded on sandy substrate. We also observed three Crown-of-Thorns Starfish *Acanthaster* sp. and a Yellow-lipped Sea Krait *Laticauda colubrina* while underwater.

Invertebrates: arachnids, butterflies, crabs

Of spiders on Narcondam, we recorded 13 taxa, including 4 identified to species based on photographs: St. Andrew's Cross Spider *Argiope versicolor* (common along the coast), Pear-shaped Leucauge *Opadomata festigata* (seen on coastal trails), Double-spotted Spiny Spider *Gasteracantha mammosa* (on coastal trails and at police camp), and a Common House Spider *Heteropoda venatoria* (on the forest floor). A large, colourful Tent Web Spider *Cyrtophora* sp., with conspicuous tent-like web and striking female colouration, appeared most common. We saw a Leucauge Spider *Leucauge* sp., and a small Comb-footed Spider *Chryso* sp. was encountered in the coastal forest in the north. We saw a large number of webs of Giant Wood Spider *Nephila* sp. (and one male, no females) up to an elevation of about 150 m. One jumping spider, *Telamonia* sp. was seen around 350 m elevation. An orb weaver *Neoscona* sp. was seen at around 427 m elevation on the second peak in the northeast of the island. Three unidentified spiders were found in the coastal vegetation near the police camp (one was possibly a humped spider, *Uloborus* sp.). A small scorpion mentioned by previous visitors to Narcondam was not seen during this survey.

Among butterfly species recorded earlier from Narcondam, we recorded Cruiser *Vindula erota*, Clipper *Parthenos sylvia*, Psyche *Euchrysops cnejus*, and what was likely a Common Gull *Cepora nerissa*, while three species were not recorded during the present survey: Glistening Cerulean *Jamides elpis*, Gram Blue *Euchrysops cnejus* and Yellow Orange Tip *Ixias pyrene*. Species recorded for the first time on Narcondam during the present survey were Common Mormon *Papilio polytes*, Danaid Eggfly

Hypolimnas misippus, Crimson Rose *Atrophaneura hector* and an unidentified grass yellow (family Pieridae).

A number of land crabs were seen at the police camp, captured by the personnel apparently for food. These are probably *Discoplax* aff. *hirtipes* and *Gecarcoidea lalandii* (syn. *G. humei*). Hermit crabs (unidentified) were plentiful along the beach.

Herpetofauna

No amphibians were seen. Among reptiles, seven species were seen on land and the Yellow-lipped Sea Krait *Laticauda colubrina* noted in adjacent waters. One snake species seen in earlier surveys – Paradise Flying Snake *Chrysopelea paradisi* – was not seen during the present survey.

In contrast to earlier reports that water monitor *Varanus salvator* was plentiful and tame on Narcondam, we saw only five very wary individuals, including one yearling (close to the police barracks) in three days. The most abundant and obvious reptiles were two species of skinks that abound in coastal and lower reaches, becoming less frequent while ascending the hills. Tytler's Skink *Eutropis tytleri*, a large skink reaching 15 cm in snout-vent length and widespread throughout the Andaman Islands, is very visible on Narcondam, but none of the individuals appeared as large as those seen commonly in the main Andaman group, and this may warrant further taxonomic examination. The Writhing Skink *Sphenomorphus maculatus*, with appearance closely resembling individuals of this species in northeast India, was the most common reptile on Narcondam, particularly near the coast and at lower elevations.

Four species of geckos were noted. One Curl-tailed Gecko *Cyrtodactylus rubidus*, with less conspicuous markings than typical *C. rubidus* seen in the main Andaman group, was seen on a tree in the police camp after dark. The Andaman Day Gecko *Phelsuma andamanense* was common both around the police camp (in the abundant banana and coconut trees) and in the coastal forest. One Verraux's Gecko *Gekko verreauxii* was heard calling in the evening but not seen. This large gecko species is widespread in the Andaman Islands. Several of the cryptic Anderson's Day Geckos *Cnemaspis andersonii* were seen on tree trunks and boulders along the ravine and dry stream bed leading to the spring.

Birds

In total, we made confirmed identifications of 25 species of birds on Narcondam, including the Narcondam Hornbill. Three additional species are tentatively noted from single detections and would benefit from confirmation: Common Kingfisher *Alcedo atthis*, Long-tailed Parakeet *Psittacula longicauda* and Siberian Thrush *Zoothera*

sibirica. Besides these 28 species, we recorded 4 unidentified bird species on Narcondam. Of the species recorded, six are new records for the island: White-breasted Waterhen *Amaurornis phoenicurus*, Slaty-legged Crake *Rallina eurizonoides*, Black-naped Tern *Sterna sumatrana*, Yellow Bittern *Ixobrychus sinensis*, Hooded Pitta *Pitta sordida* and Pacific Swallow *Hirundo tahitica* (Common Kingfisher will also be a new record for Narcondam, if confirmed). The Slaty-legged Crake is a new record for the Andaman and Nicobar Islands. These records taken with the compilation of observations across all previous observers bring the total number of confirmed bird species on Narcondam Island to 49, with 2 other possible species being the Oriental Turtle Dove *Streptopelia orientalis* and Andaman Scops Owl *Otus balli* (Appendix 1).

Narcondam Hornbill

There were 36 detections (individuals or flocks) of Narcondam Hornbill with an average flock size of 1.88 (\pm SE = 0.21). Single individuals were most frequent, followed by pairs (Figure 2). One aggregation (not flock) of about 12 hornbills was seen at a copiously fruiting *Ficus* tree. During the survey, hornbills seemed common in the lower slopes, with only three detections during the attempted peak ascent, two at lower elevations and one in the forests at around the highest elevation attained (427 m).

Both males and females, of various ages (judging by the lines on the casque), were seen. Of 49 individuals seen in flocks where at least one individual could be classified, 28 were males, 13 were females, 1 was a juvenile and 7 could not be classified. Two nests and a midden were seen during the survey. One nest, visited by a male and a female, was approximately 30 m high up on the trunk of a *Tetrameles nudiflora* tree draped in lianas along the ravine trail. The midden had *Ficus* sp. and

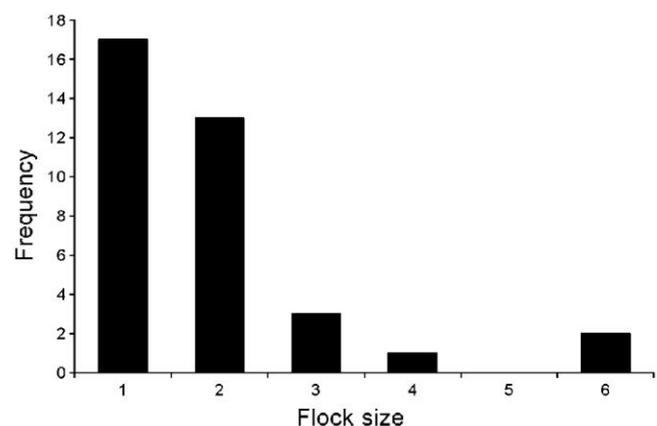


Figure 2. Flock size distribution of Narcondam Hornbill on Narcondam Island (April 2010).

Caryota mitis seeds. The other nest was close to the beach (about 20 m from the water edge) on the lighthouse trail, on the primary branch of a *T. nudiflora* tree at about 20–25 m height. A male was seen bringing food (including *Ficus* sp., *Canarium* sp., *C. mitis* and an unidentified *Sapindus*-like fruit) to a chick (one was visible in the nest). To minimize disturbance, we did not remain long near the nests to make any extended observations.

We recorded 53 detections of Narcondam Hornbill within 150 m perpendicular distance of the three surveyed trails (ravine trail = 10 + 10, lighthouse trail = 12 + 8 and hillslope trail = 13 detections). This indicates an average encounter rate of 7.0 (\pm SE = 1.05) hornbills clusters/km. The density estimation results also suggest a high density in the vicinity of the police barracks in this season. The average cluster density of 88.5 hornbills/km² indicates a hornbill density of 167 individuals/km² (95% CI = 63.3 – 271 hornbills/km²) along the three non-randomly located survey trails during the breeding season of April 2010 (Table 2; Figure 3).

Mammals

Three large fruit bats were noticed roosting among a tangle of lianas in a tree in the evergreen forest. Based on field observations and photographs, we identified this species as the Island Flying Fox *Pteropus hypomelanus*. A small bat (Megachiroptera or microchiroptera) was also seen flying in the forest understorey, but could not be identified. One species of rat abounds on the island (probably the Indo-Chinese Forest Rat, *Rattus andamanensis*), which we noted in abundance around the police camp, especially after dark. We had no sightings of feral Domestic Goat *Capra hircus* or signs of its presence (tracks, pellets) during the survey, although camp

Table 2. Results of Narcondam Hornbill density estimation from observations along three non-randomly placed survey trails near police barracks, Narcondam Island

Item/parameter	Value
Number of trails	3
Number of repeats	2, 2, 1
Total line length (km)	7.95
Number of clusters	53
Model	Hazard rate
Adjustment	–
Detection probability (SE)	0.25 (0.057)
Effective strip width (m; SE)	37.7 (8.56)
Density of clusters (number/km ² ; SE)	88.5 (26.42)
%CV of cluster density	29.9
95% CI of cluster density	46.3–169.0
Average flock size (SE)	1.89 (0.21)
Number of flocks	36
Density of hornbills (number/km ² ; SE)	167.1 (52.93)
%CV of hornbill density	31.7
95% CI of hornbill density	63.3–270.8

personnel reported seeing two goats on the western side of the island in the recent past.

Discussion

Despite the short duration of the present survey, we added records of species new to the island checklist and made preliminary observations on some marine life and lesser known terrestrial fauna. It is clear that more work is required to properly document the island's biological diversity (Figures 4 and 5) through better inventory and seasonal sampling.

The four dives off Narcondam were exploratory in nature. The coral growth observed, particularly in the northeast and southern dive locations, was among the best seen anywhere in the Andaman Islands (U. Mistry and T. Khan, per. obs.). The sizes of barrel sponges suggested an ideal, nutrient-rich environment for growth, with the strong currents in the reef slopes potentially assisting in their process of filter-feeding. Like Barren Island, there is a conspicuous lack of anemones on Narcondam's reefs, and a greater density of demosponges (class Demospongiae) compared to other reefs around the Andaman Islands.

The remote location of Narcondam, combined with a large depth gradient and proximity to pelagic environment, led us to expect a high biomass of apex predators^{35–37}, and provide insights into reef structure and productivity prior to human extraction³⁸. The striking absence of these apex predators suggests, however, that the area may be fished regularly (see Recent Threats and Conservation Prospects). Even coral groupers commonly found in other parts of the Andaman Islands were few in number. It would be valuable to conduct a detailed assessment of the reef structure, reef fish assemblage and fishing frequency at Narcondam Island. Ecological studies of ecosystems that face little or no human impacts provide fundamental insights for conservation and restoration^{38,39}. Considering the geographic isolation and location of the island, along

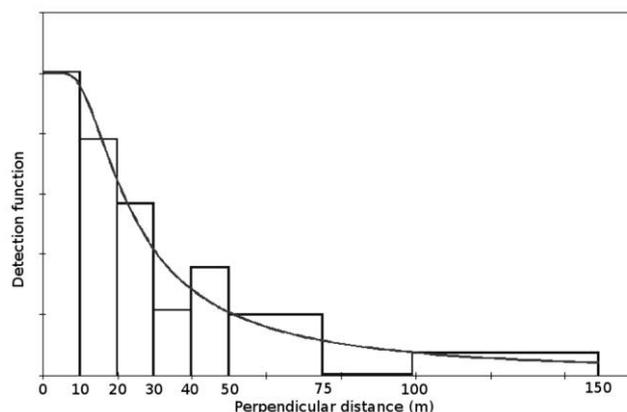


Figure 3. Hazard-rate detection function fit to distance sampling data for Narcondam Hornbill.

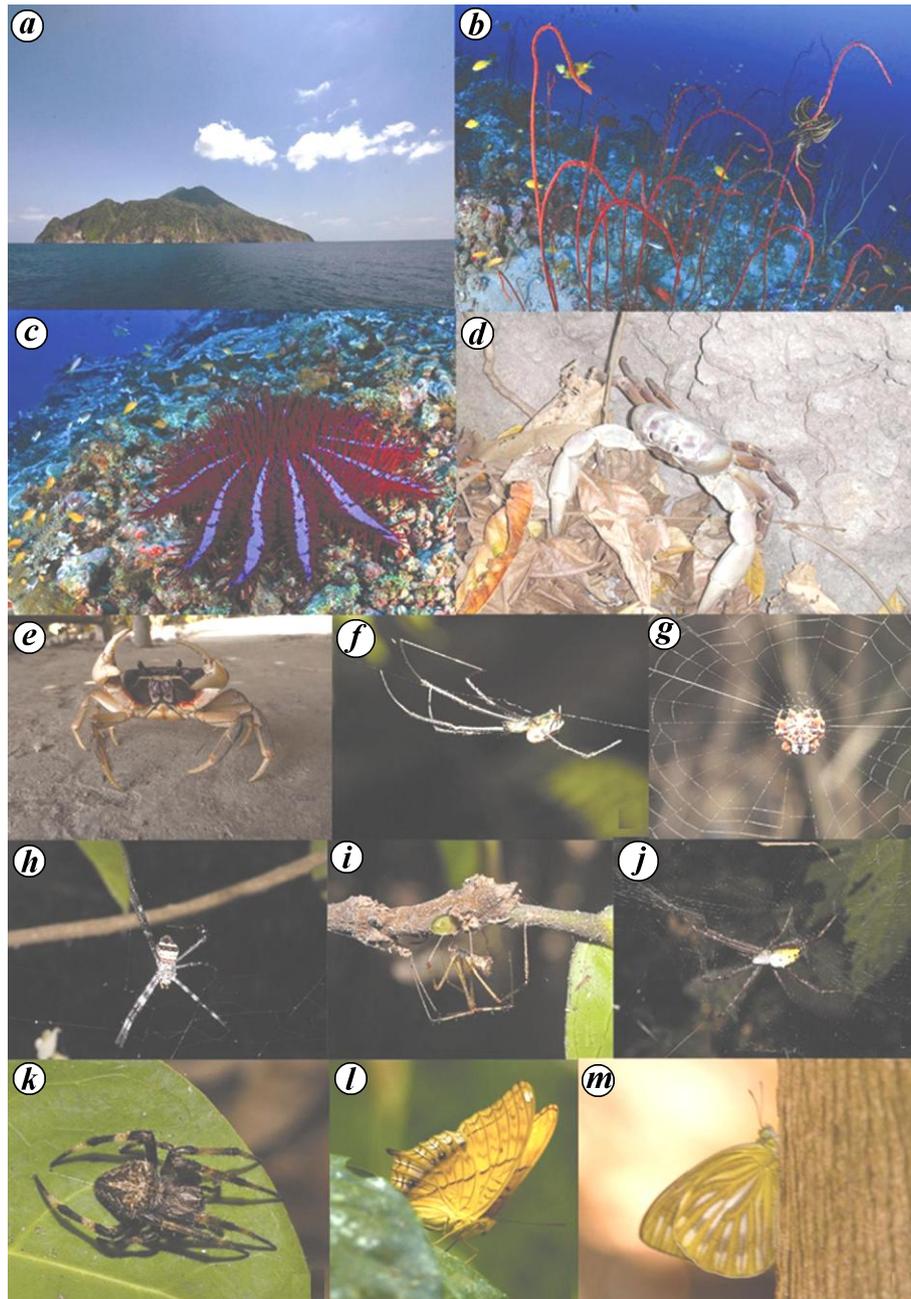


Figure 4. Photographs from the survey: (a) Narcondam Island; (b) Whip coral *Leptogorgia* sp.; (c) Crown-of-Thorns Starfish *Acanthaster planci*; (d) Hume's land crab *Gecarcoidea humei*; (e) Orange-faced land crab *Discoplax hirtipes*; (f) Pear-shaped Leucauge *Opadomata festigata*; (g) Double-spotted Spiny Spider *Gasteracantha mammosa*; (h) female multicoloured St. Andrew's Cross Spider *Argiope versicolor*; (i) Comb-footed Spider *Chryso* sp.; (j) female Tent-web Spider *Cyrtophora* sp.; (k) *Neoscona* sp.; (l) Cruiser Male *Vindula erota* and (m) Common Gull *Cepora nerissa*.

with the pristine coral observed, the area has potential as a comparative or control site for studies of similar isolated islands that have suffered anthropogenic and climate-change impacts. Narcondam also has potential as an ideal site to assess resilience of coral reefs after the 2010 El Nino that caused extensive damage to the shallow reefs in the region⁴⁰.

A more extensive survey, especially soon after the northeast monsoon, is likely to yield a more diverse arachnid fauna, as revealed for instance in a recent survey of spiders in the Maldives⁴¹. The *Cyrtophora* seen on Narcondam could not be identified to species from the available literature and so far this spider has not been recorded in the Andaman and Nicobar Islands. On oceanic

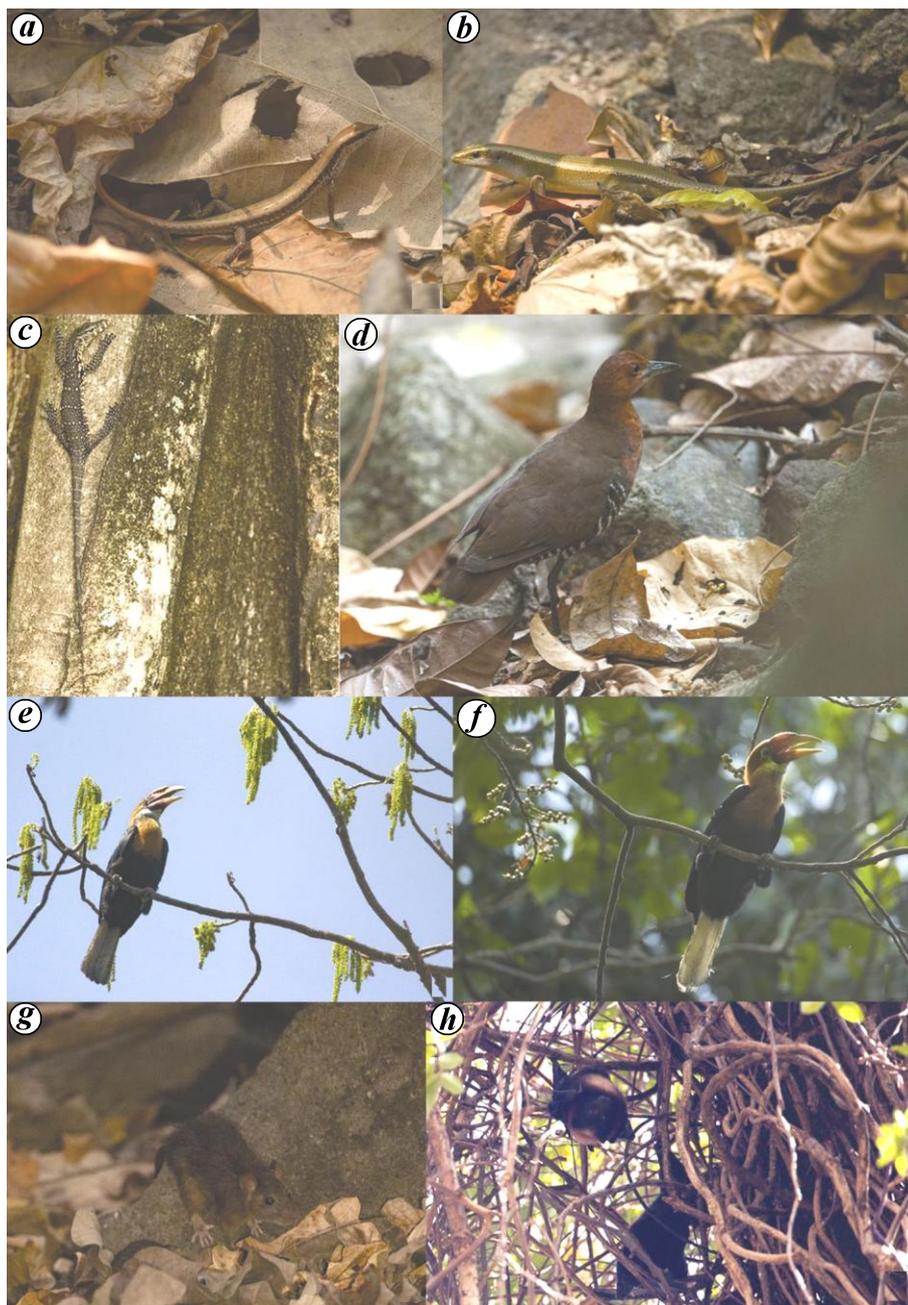


Figure 5. Photographs of some vertebrates recorded on Narcondam: (a) Writhing Skink *Sphenomorphus maculatus*; (b) Tytler's Skink *Eutropis tytleri*; (c) Water monitor lizard yearling *Varanus salvator*; (d) Slaty-legged crane *Rallina eurizonoides*; (e, f) Narcondam Hornbill *Rhyticeros narcondami*; (g) Indo-Chinese Forest Rat *Rattus andamanensis* and (h) Island Flying Fox *Pteropus hypomelanus*.

islands, spiders are also interesting from the biogeographic perspective of colonization, radiation and endemism⁴². Given its dense vegetation, altitudinal variation, availability of freshwater, volcanism and geographic isolation, Narcondam has the potential to throw up interesting discoveries in future surveys. Prain⁴³ had recorded seven species of butterflies in Narcondam, of which we recorded four species during the present survey. Among the additions to the butterfly fauna are three identified and one unidentified species. These differences may be merely due to the short duration of the earlier and present

surveys and the lack of information from intervening periods. Other invertebrates recorded earlier from the island include two beetles, *Chrysochroa ignita* and *Mimila prenceps*, and land crabs *Cardisoma hirtipes*⁴⁴. The latter correspond to the species noted during the present survey, which is probably *Discoplax* aff. *hirtipes*⁴⁵, and the other species is probably *Gecarcoidea lalandii* (syn. *G. humei*; P. K. L. Ng, pers. commun.).

As in earlier surveys, no amphibians were recorded from the island, possibly due to the presence of only one identified freshwater source. Water monitors—noted by

Prain⁴³ to be very common and allowing people to approach to nearly touching distance—appeared much scarcer and shyer during the present survey. An earlier report⁴⁶ noted hunting of water monitor lizards by police personnel stationed on the island. The extremely high abundance of rodents noted on the island may at least partly be due to decreased abundance of monitors. Prain⁴³ mentions a ‘small sandy beach in North Bay, frequented by turtles where monitor lizards are common ...’. We visited this small beach, not far from the new lighthouse, but there were no signs of sea turtles (at least at this time of the year, which is after the normal sea turtle nesting period between November and March on the islands, and vegetation had grown over much of the beach), or monitors. The terrestrial Paradise Flying Snake *Chrysopelea paradisi* reported and collected from Narcondam in earlier surveys⁴⁷ was not recorded on this visit, probably due to the dry weather and the short duration of the survey. Our record of the Andaman Day Gecko *Phelsuma andamanense* reconfirms its occurrence on Narcondam, the eastern and northernmost extent of the range of the genus. We note the absence of the distinctive ‘tik–tik–tik–tik’ crepuscular call indicating absence of House Geckos *Hemidactylus frenatus*, surprising as this gecko is common almost all around the tropical world.

Significantly, our short survey added at least six bird species to the island checklist, with a possible seventh being the Common Kingfisher. Although a number of ornithologists have visited the islands earlier, later visits were primarily related to observing or studying the Narcondam Hornbill (Table 1). It is likely, therefore, that the bird species recorded for the first time on the island in this survey were species overlooked by earlier observers and not necessarily new colonizations of the island.

Past efforts to estimate the population of Narcondam Hornbill have been limited and variable in quality and method. Osmaston¹⁶ collected ten Hornbill specimens and made a ‘liberal estimate’ of not more than 200 hornbills on the island. Based on his 1972 survey, Hussain⁴⁸ similarly made a higher ‘liberal estimate’ of around 400 birds. Around 1998, biologists estimated a population of less than 350 birds on Narcondam, representing a decline from around 400 individuals earlier¹⁴. A brief survey in March 2000, which used two different line transect methods estimated a hornbill density of 72/km² and 83/km², suggesting a population of 432 or 498 birds over 6 km² of available habitat as estimated for Narcondam⁴⁹. Unfortunately, due to differences among methods, lack of information on location of trails and sampling effort across these publications, these estimates are not comparable.

The density of Narcondam Hornbill estimated during the present short survey from the non-random trails surveyed is much higher than earlier reports (88.5 hornbill clusters/km² or 167 individuals/km² with a wide 95% confidence interval of 63.3–271 individuals/km²). We

emphasize that the density noted here, although suggestive of abundance, should not be extrapolated to the island as the trails surveyed were non-random. Compared with studies on other hornbill species, these are among the highest densities reported for hornbills. For instance, in the Anamalai hills of southern India, the Malabar Grey Hornbill, the smallest and most abundant of hornbills for which density estimates are available^{50,51}, occurs at a density between 51.5 and 67.4 birds/km². Studies of other hornbill species from Southeast Asia^{7,52} have revealed densities between less than 1/km² and 51/km². In Sulawesi, studies⁷ showed that the population of Red-knobbed Hornbills *Aceros cassidix* fluctuated on a monthly basis between 9/km² and 84/km² in correlation with availability of fig fruits, while monthly density of larger hornbills varied between 1/km² and 12/km². The high density of Narcondam Hornbill noted in the present survey may be because our sampling was during the breeding season in Narcondam in an area where hornbills are concentrated in the lower elevations. Also, our sampling was carried out along the ravine and trails at lower elevations, which possibly had a higher density of nest (*T. nudiflora*) and food (e.g. *Ficus* and *C. mitis*) trees than higher slopes and other locations on the island. Earlier studies¹⁴ have reported that most Narcondam Hornbill nests are located at lower elevations (below 100 m: 60% of nests; below 300 m: 98% of nests) and virtually all roost sites are also located below 300 m.

Given the non-random placement of trails, breeding seasonality and food availability, and that hornbill densities at a given location are known to fluctuate by at least one order of magnitude, the high densities reported during the present study must be taken as only representing the specific trails and season. Since access to other parts of the island is limited during short visits, future estimates of hornbill encounter rates along the same trails can be compared with the present survey (7.0 ± 1.05 SE, hornbill flocks/km). To reliably estimate the population density and size of Narcondam Hornbill, we emphasize the need for a well-designed, longer duration line transect survey, with random placement of transects across the island.

Besides direct observations of nests and breeding, the observed sex ratio of Narcondam Hornbill (over twice as many males as females) suggests that many females were incarcerated in their nests. A few juveniles were also seen, indicating breeding in previous years as well. As the first survey after the 2004 tsunami, the present survey suggests that the Narcondam Hornbill appears to be still relatively common and breeding on the island.

Among mammals, further research on the bats of Narcondam, particularly echo-location call recordings or mist-net surveys to identify species, and foraging and seed dispersal studies, would be useful. It would also be useful to establish through ecological and genetic studies whether the rats on the island are an introduced popula-

tion or natural colonists, and their present impacts, if any, on the forest regeneration through seed predation.

Recent threats and conservation prospects

Major threats related to conservation in Narcondam in the recent past are discussed below.

Poaching: Vijayan and Sankaran¹⁴ noted eight hornbills shot using catapults by personnel at the police camp during the three months preceding their study and estimated that at least 30–45 hornbills were thus killed annually (besides imperial pigeons and other species). Hunting water monitors for the pot was also noted in a 2007 report⁴⁶. The Department of Environment and Forests (DoEF-A&N) and scientists working in Narcondam have however spread greater awareness among camp personnel on the threats facing the species and the ban on hunting under the Wild Life (Protection) Act of 1972. Since camp personnel change periodically and water monitors appear to be shy and scarce, we suggest the need for strictures, posting of orders and notices, regular awareness programmes against hunting, provision of canned or dried meat for camp personnel to prevent hunting, and systems for removal of non-biodegradable material to other islands or the mainland for safe disposal or recycling.

Longline and shark fishing: There have been reports of poaching in the waters around Narcondam. Off the southwestern side of the island we found direct evidence of longline fishing, and noted a long stretch of discarded shark-fishing lines with buoys hanging between 10 and 20 m and continuing further into the depths. Exploitation of apex predators in isolated systems can lead to trophic cascades⁵³. Therefore, in addition to effective patrolling, periodic surveys to assess fish and coral assemblage may help develop a baseline of reef fish assemblages. As one of the few examples of isolated coral reefs in the Andaman chain, supporting high-diversity populations of fish and other species, Narcondam is likely to be sensitive to disturbances with low ability to recover because of its isolation.

Feral goats: Prain⁴³ notes that goats were landed on Narcondam and Barren ‘more than once’, but none was noticed during his visit, which he suggests is because ‘... for a considerable portion of the year the island is waterless’. Introduction of a handful of goats as a food source for the police outpost in 1976 led, however, to the population of goats booming to around 400 in 2000, over half being feral. In 1991, ‘rapid proliferation’ and consequent detrimental impact on forest vegetation were noted by Hussain⁵⁴ and later by others¹⁴, posing a major threat to the future of the hornbill’s habitat. Biologists recommended removal of goats from the island and the DoEF-A&N and Police Department acted to remove nearly all

of them from the island. The continued presence of a few feral goats, noted by police personnel on the island, is a matter of concern and if they persist, then attempts should be made to monitor the situation and remove the remaining goats as early as possible before their numbers increase. A more recent month-long (10 July–10 August 2012) survey of hornbills recorded no sightings or signs of feral goat (S. Manchi, pers. commun.).

Habitat disturbance and weed invasion: The police outpost of some 30-odd staff has already resulted in loss of around 20 ha on the island for the camp and plantations of coconut, arecanut, banana, and vegetables, besides continuing disturbance through lopping of trees for firewood and invasion of alien plants such as *Chromolaena/Eupatorium* (refs 14 and 54). We reiterate the need to minimize habitat disturbance and spread of invasive species with the cooperation of the police staff.

Proposal for radar and diesel power generation station: On 14 October 2011, a proposal was tabled by the Indian Coast Guard before the Standing Committee of the National Board for Wildlife (SC-NBWL) to install a radar and diesel power generation station on Narcondam. A site inspection on 7 February 2012 led by A. R. Rahmani of the Bombay Natural History Society noted serious concerns such as destruction of habitat due to road construction, impacts on the fragile island and threats to viability of hornbill population, and the report recommended rejection of the proposal. From late June 2012 onwards, conservationists, including some of the present authors, wrote to the Minister of State for Environment and Forests, with scientific results of earlier studies and highlighting threats to the endemic hornbill, island habitat, and surrounding waters by such a project, and requested the Minister as Chairperson of the SC-NBWL to reject the proposal. This along with a subsequent nation-wide conservation campaign and media coverage of the threats, culminated in the Ministry of Environment and Forests (MoEF) rejecting the Coast Guard proposal (F. No. 6-73/2011, WL, 31 August 2012, <http://moef.nic.in/assets/wl-04092012.pdf>). The Indian Navy and Coast Guard have been supportive of conservation and instrumental in some of the previous surveys^{49,55,56}, and should continue to adopt this forward-looking role to aid in conservation of Narcondam and other islands in the region. Although this threat has been staved off for now, it is an important case and precedent emphasizing the importance of according the highest level of protection for ecologically unique and sensitive islands such as Narcondam⁵⁷.

Conclusions

The action by the MoEF to reject permission for harmful installations, the management measures by DoEF-A&N

to issue strictures against hunting, the removal of feral goats from Narcondam with the help of police staff, and the results of the present survey together suggest that the present conservation status of Narcondam is positive. During this survey, live chicken were found at the police camp and the DoEF took up the matter with the police authorities to ensure that no live chickens is taken to Narcondam in the future. As mentioned above, however, there is a need for continuous engagement with the police camp, as long as it remains on the island, to create awareness on protection, avoid hunting, and reduce habitat disturbances. Further, there is a need for regular surveys of Narcondam to document the island's biological diversity, forest regeneration, annual trail-based hornbill monitoring, and periodic island-wide transect surveys for robust estimation of hornbill population. The initiation of a long-term research project on Narcondam Hornbill by the Sálím Ali Centre for Ornithology and Natural History (SACON), Coimbatore, with funding support from the MoEF is a positive and timely step. The DoEF-A&N and MoEF should continue to foster such conservation efforts and field research in Narcondam.

We also suggest that the police outpost be replaced by a low-impact, long-term, multi-disciplinary scientific research station (also suggested earlier⁵⁸), with reduced police staff coupled with the removal of plantations and restoration of degraded vegetation in the vicinity of the present police camp. A well-designed, low-impact field research station permanently manned by a small team of scientists, rotating staff of employees, and volunteers screened for their abilities, can be established with government support. The station may be operated by a consortium of organizations with commitment and interest in research and monitoring in diverse areas of science such as ecology, evolution, biogeography, geology, oceanography and marine biology, with primacy accorded to island protection and conservation.

Appendix 1. Annotated list of bird species recorded on Narcondam Island

YELLOW BITTERN *Ixobrychus sinensis*

A new record for Narcondam, one individual was seen near the lighthouse during this survey.

CHINESE POND HERON *Ardeola bacchus*

One injured bird was seen near the police barracks, which died the next day. Species also recorded by Abdulali⁴⁷.

INTERMEDIATE EGRET *Mesophox intermedia*

This egret was seen along the coast and also seen and photographed near the police barracks. There is an earlier record on Narcondam⁴⁶.

PACIFIC REEF EGRET *Egretta sacra*

Reported as common by earlier observers, including by Abdulali⁶¹ who noted that all individuals were of the dark grey colour phase. During the present survey, individuals of both light and dark phase were seen along the coast.

WHITE-BELLIED SEA EAGLE *Haliaeetus leucogaster*

A resident breeding on the island, noted by earlier observers. A nest and juvenile were seen during the present survey and an adult was seen being mobbed by a pair of Narcondam Hornbills in the forest.

SLATY-LEGGED CRAKE *Rallina eurizonoides*

This crane was seen along a forest ravine. It was not shy and approached very close to the observers, even pecking at the footwear of one person. This represents the first record of the species from the Andaman and Nicobar Islands³⁰.

WHITE-BREADED WATERHEN *Amaurornis phoenicurus*

This was seen near the police barracks and is a new record for Narcondam island.

LESSER SAND PLOVER *Charadrius mongolus*

Noted as rather common by Prain⁴³ and not recorded by any observer since.

WHIMBREL *Numenius phaeopus*

Seen along the shore, this species has also been reported earlier by Abdulali (refs 47, 61).

COMMON SANDPIPER *Actitis hypoleucos*

Seen on rocks along the shoreline, this winter migrant¹⁶ has been reported to be very common by Prain⁴³, and frequent by Abdulali⁶¹.

RUDDY TURNSTONE *Arenaria interpres*

Not seen during the present survey or recorded by any observer besides Osmaston¹⁶.

BLACK-NAPED TERN *Sterna sumatrana*

A few individuals were seen flying over the ocean near the landing point. This is a new record for Narcondam island.

WHITE TERN *Gygus alba*

Not seen during the present survey; the only record⁶⁴ from Narcondam waters is from March 2000.

BRIDLED TERN *Onychoprion anaethetus*

One male recorded by Abdulali⁴⁷ on the boat off Narcondam appears to be the only record of this species for the island.

GREEN IMPERIAL PIGEON *Ducula aenea*

Seen in the forest canopy during the present survey. Noted also by earlier observers^{43,46,47,61}.

PIED IMPERIAL PIGEON *Ducula bicolor*

Several individuals were seen perched on tree tops and flying over the canopy, although only one individual was seen in the vicinity of 'Pigeon Island', the large rock offshore the northern tip of Narcondam, during the present survey. Prain⁴³ noted the species to be exceedingly plentiful and Osmaston¹⁶ also noted it as fairly common near the shore; the latter believed it to be resident, unlike the earlier observers (Hume and Prain), who believed it to be a seasonal visitor. Abdulali⁶¹ noted nesting colony on small island off north coast, found eight nests on a 12-ft tall tree with single eggs or chicks in each, and estimated 100 nests for the area.

ORIENTAL TURTLE DOVE *Streptopelia orientalis* (?)

Abdulali⁶¹ reports that this was noted twice, but not confirmed.

ANDAMAN GREEN PIGEON *Treron (pompadora) chloropterus*

Not seen during the present survey, but six individuals were sighted (reported as Andaman Green-Pigeon *Treron chloropterus*) earlier⁴⁶.

EMERALD DOVE *Chalcophaps indica*

One bird seen flying through a ravine. Osmaston¹⁶ collected a single specimen and noted that the species was apparently rare. A few later records were made by Abdulali^{47,61}.

RESEARCH ARTICLES

NICOBAR PIGEON *Caloenas nicobarica*

Not seen during the present survey. Prain⁴³ reports that the species was noticed several times on Narcondam, possibly as a visitant from the Nicobars. There have been no subsequent reports or records.

ALEXANDRINE PARAKEET *Psittacula eupatria*

Heard and seen in forests; noted to be frequent or common by earlier observers such as Osmaston¹⁶ and Abdulali⁶¹.

LONG-TAILED PARAKEET *Psittacula longicauda*

A single sighting above the cleared area north of the barracks; but would benefit from added confirmation. Although noted by Prain⁴³ to be common, Osmaston¹⁶ did not see or hear this species and thought that the earlier record may be a mistake; a suggestion reiterated by Abdulali⁶¹.

HIMALAYAN CUCKOO *Cuculus saturatus*

Not seen on the present survey; a single individual reported only more recently by Pande *et al.*⁴⁶.

ASIAN KOEL *Eudynamis scolopacea*

Seen and heard in the forests the present survey. Also recorded by most previous observers.

ORIENTAL SCOPS OWL *Otus sunia*

Not recorded during the present survey. One individual caught by Abdulali (ref. 61) and calls heard were presumed to be this species. The Andaman Scops Owl *Otus balli* is also reported⁶⁵ to occur in Narcondam, although we could not trace any confirmed reports.

ANDAMAN NIGHTJAR *Caprimulgus andamanicus*

Formerly treated as an Andaman subspecies of the Large-tailed Nightjar *C. macrurus*, this was noted by Abdulali⁶¹ based on the 'chaunk chaunk' call heard at night. The call of *C. andamanicus* is reported³⁰ to be different from *C. macrurus*.

DOLLARBIRD *Eurystomus orientalis*

One individual was seen flying over the forest canopy. Abdulali⁴⁷ also records one female, possibly of interesting subspecific status.

BLACK-CAPPED KINGFISHER *Halcyon pileata*

Not seen on the present survey. Prain⁴³ saw several individuals perhaps of this species, while Osmaston¹⁶ collected two specimens, and noted that it was presumably rare. Abdulali⁴⁷ recorded one being chased by a hawk *Accipiter* sp. and solitary birds were seen in 1972 (ref. 61).

COMMON KINGFISHER *Alcedo atthis*

One individual was seen from quite far sitting on rocks along the coast. We treat this as a record requiring additional confirmation as Abdulali⁶⁶ notes that one individual collected by him elsewhere in the Andamans believing it to be Common Kingfisher turned out, on closer examination, to be Blue-eared Kingfisher *Alcedo meninting*, which was reportedly more common in the region.

BLUE-TAILED BEE-EATER *Merops philippinus*

Not seen on the present survey. Osmaston¹⁶ noted it as a winter migrant. Abdulali⁶¹ also notes one female, but is unclear whether it was reporting Osmaston's record.

NARCONDAM HORNBILL *Rhyticeros narcondami*

Common and widespread on the island (see text) as noted by all earlier observers from Prain⁴³ who found it 'exceedingly plentiful' and 'very far from shy'.

HOODED PITTA *Pitta sordida*

A new record for Narcondam, one individual was repeatedly seen in dense forest along the ravine from which water is sourced for the barracks.

BROWN SHRIKE *Lanius cristatus*

A few were seen on Narcondam in an earlier survey⁶¹; not recorded during the present survey.

ASHY DRONGO *Dicrurus leucophaeus*

Not seen during the present survey; recorded by Abdulali⁶¹.

BARN SWALLOW *Hirundo rustica*

Not seen during the present survey; noted as a common migrant along shore and near summit by Osmaston¹⁶ and as present on the island by Abdulali⁶¹.

PACIFIC SWALLOW *Hirundo tahitica*

A few individuals were seen hawking insects over water from the anchored boat – a new record for Narcondam.

THICK-BILLED WARBLER *Phragmaticola aedon*

Abdulali⁶¹ records one male; the species was not seen during the present survey.

DUSKY WARBLER *Phylloscopus fuscatus*

Two individuals collected by Abdulali⁶¹ constitute the only confirmed record from the island. It was not seen during the present survey.

YELLOW-BROWED WARBLER *Phylloscopus inornatus*

Seen foraging in the canopy and its call was also distinctly heard.

PALE-LEGGED LEAF WARBLER *Phylloscopus tenellipes*

Not seen during the present survey; three males were collected by Abdulali⁶¹.

COMMON HILL MYNA *Gracula religiosa*

Many individuals and small flocks were seen and heard in forest canopy. The species has been recorded earlier^{47,61}.

SIBERIAN THRUSH *Zoothera sibirica*

Abdulali⁶¹ records collecting one specimen from a party of four. During the present survey, a thrush with a scaly underside was seen in dense forest understorey, probably a female of this species. It was seen in the same ravine at least thrice; however, the poor visibility precluded firm confirmation of identity.

EYEBROWED THRUSH *Turdus obscurus*

Not recorded during the present survey, but noted earlier by Abdulali⁴⁷.

ASIAN BROWN FLYCATCHER *Muscicapa dauurica*

One individual recorded by Abdulali⁶¹; not recorded during the present survey.

TAIGA FLYCATCHER *Ficedula albicilla*

One individual seen on rocks by the coast was probably this species; also noted in an earlier survey as *Muscicapa parva albicilla* in Abdulali⁶¹.

OLIVE-BACKED SUNBIRD *Cinnyris jugularis*

Common on the islands, with many birds singing and males in breeding plumage observed. Also recorded as common by earlier observers.

FOREST WAGTAIL *Dendronanthus indicus*

Seen in the forest understorey, this species has also been recorded earlier^{16,61}.

YELLOW WAGTAIL *Motacilla flava*

Seen on rocks near the shoreline, as noted in earlier survey⁶¹.

GREY WAGTAIL *Motacilla cinerea*

Not seen during the present survey. Recorded earlier as winter migrant¹⁶, with two males in almost full breeding plumage in March–April 1972 (ref. 61).

RED-THROATED PIPIT *Anthus cervinus*

Not seen during the present survey; one was reported by Abdulali⁶¹ as seen at forest edge.

Unidentified species

The following observations constitute unidentified bird species for Narcondam:

- i. A small blue-grey bird skulking, like a robin or warbler, in low ferns in dense forest (present survey).
- ii. Swallow (*Hirundo* sp.): Abdulali⁴⁷ noted a swallow with whitish underparts and longish forked tail soaring high over island. Swallows with white bellies were seen from a distance during the present survey and may have been *H. rustica*.
- iii. Swiftlet (*Collocalia* sp.): Prain⁴³ reported the Rock Swiftlet *Collocalia linchi* (= Cave Swiftlet) seen along the coast caverns. The identity was assumed as no (edible) nests were seen. It is noted in a footnote that if reports of edible nests are true then the assumed identity of the species is doubtful. Osmaston¹⁶ reported that those, seen hawking around the summit and probably breeding in caves along the coast were Hume's Swiftlet *C. immominata*. Also noted as *C. brevirostris immominata* by Abdulali^{47,61}, who wondered if Osmaston's record should be accepted as no specimens were collected. Although, 'thousands' were seen at the summit, he concluded that identification remains doubtful. During the present survey, many swiftlets were seen flying around the peak and over the forest (through canopy gaps), but their identity could not be firmly established.
- iv. Swift (*Apus* sp.): A large black swift seen high over the island^{47,61}.
- v. Eagle (*Spilornis* sp.): An eagle was seen soaring over the Narcondam peak, but was too far away to identify conclusively.
- vi. Hawk (*Accipiter* sp.): Two individuals noted by Osmaston¹⁶ as *Astur?*, circling high over the mountain may have been accidental visitors according to him. An *Accipiter* sp. was also noted by Abdulali⁴⁷ as chasing a Black-capped Kingfisher.

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ACKNOWLEDGEMENTS. We thank the Department of Environment and Forests, Andaman and Nicobar Administration, and the Coast Guard for permissions to visit Narcondam for the survey. We are grateful to Eleni Foui, P. Jeganathan, Aaron Lobo, Rohan Pethiyagoda, Peter Ng and Nachiket Kelkar for help with identification and references, and Rohan Arthur for helpful comments. We also thank the reviewers for comments that helped improve the manuscript and Nick Band for making our journey both safe and enjoyable. The expedition was undertaken using personal funds without any external financial support.

Received 10 November 2012; revised accepted 28 May 2013