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Registered Office: 3A2 Varadarajulu Nagar, FCI Road, Ganapathy, Coimbatore, Tamil Nadu 641006, India
Ph: +91 9385339863 | www.threatenedtaxa.org
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Cover: A bag worm with its beautiful heap of junk. Acrylics on 300 GSM paper by Dupati Poojitha based on a picture by Sanjay Molur.

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COMMUNICATION

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Breeding tern colonies on the sandbars of Adam's Bridge, India: new records and significance

H. Byju [1], H. Maitreyi [2], N. Raveendran [3], D.A. Marshal [4] & S. Ravichandran [5]

[1,2,5] Centre of Advanced Study in Marine Biology, Annamalai University, Parangipettai, Tamil Nadu 608502, India.
[5] Department of Zoology, Government Arts and Science College, Nagercoil, Tamil Nadu 629004, India.
[3] Iragukal Amritha Nature Trust, 61, Ramachandra Thadaga Street, Thirumangalam, Madurai, Tamil Nadu 625706, India.
[4] Wildlife Division, Gulf of Mannar Biosphere Reserve, Ramanathapuram, Tamil Nadu 623521, India.
[1] byjuhi@gmail.com (corresponding author), [2] maithgd@gmail.com, [3] iant.ravee@gmail.com, [4] dominicmarshal007@gmail.com, [5] sravicas@gmail.com

Abstract: We conducted surveys on the Indian side of Adam's Bridge sandbars that separate Rameswaram Island of India and Sri Lanka, in collaboration with the forest department. We report new breeding colonies of five tern species: Greater Crested, Saunder's, Roseate, Little, and Bridled Terns. Preliminary surveys (2023) followed by rigorous surveys (2024) confirm these sandbars as critical breeding habitats.

Keywords: Breeding colony, Bridled Tern, central Asian flyway, Greater Crested Tern, habitat selection, Little Tern, marine, population estimate, Roseate Tern, Saunder's Tern, seabirds.

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Author details: Byju H, has worked on the shorebirds and waterbirds in the Gulf of Mannar region for a decade and at present a member of the biodiversity panel of five bird sanctuaries including four Ramsar sites and the Gulf of Mannar Biosphere Reserve. Maitreyi H is a research scholar working on seabirds in the region. Raveendran N is a naturalist with a decade of experience in birds and awareness education and serves as a biodiversity member in the bird sanctuaries and Gulf of Mannar Biosphere Reserve. Ravichandran S is a professor with three decades of experience in marine ecology and oceanography. D.A. Marshal is a biologist in Gulf of Mannar Wildlife Division.

Author contributions: BH—conceptualization, writing, editing and supervision; MH—writing, editing, data management and maps; RN—data curation; SR—editing and overall supervision; MDA—data curation

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INTRODUCTION

Seabirds are key indicators of marine ecosystem changes (Schreiber & Burger 2001; Gaston 2004) due to their long lifespans (Parsons et al. 2008) and dependence on terrestrial breeding habitats and marine food sources (Ballance 2007). Central to marine ecological research (Frederiksen et al. 2006; Zador et al. 2013), seabirds reflect anthropogenic and environmental impacts, including climate change (Barbraud et al. 2008), fisheries impact (Einoder 2009; Le Corre et al. 2012), and prey stock availability (Piatt et al. 2007; Lyday et al. 2015) supporting marine conservation efforts (Bibby et al. 2012).

Terns (family Sternidae) are a globally distributed seabird group comprising over 40 species (Gochfeld & Burger 1996); 19 are recorded within Indian borders (Praveen et al. 2016). Nine species breed along Indian coasts and sandbars (Mondreti et al. 2013) underscoring the ecological significance. Historical reports on seabird breeding including Roseate Tern *Sterna dougallii* (Abdulali 1942), Black-naped Tern *Sterna sumatrana* (Blyth 1846; Abdulali 1942, 1967), Bridled Tern *Onychoprion anaethetus*, Sooty Tern *Onychoprion fuscata*, Lesser Crested Tern *Thalasseus bengalensis* and Gull-billed Tern *Gelochelidon nilotica* (Abdulali 1942), primarily reported from the Andaman and Nicobar Islands, with Sooty Tern (Kurup & Zacharias 1994; Mathew et al. 1991) from Lakshadweep Island. Breeding of Little Terns (Balachandran et al. 2005; Li et al. 2009), Gull-billed Terns (Abdulali 1942; Balachandran et al. 2005; Li et al. 2009), and Whiskered Terns (Li et al. 2009) were recorded from Chilika Lake; Gull-billed Terns in Kolleru and Godavari (Li et al. 2009) and Sundarbans (Stanford 1937); Greater Crested Terns in Sundarbans (Li et al. 2009); and Whiskered Terns in Karavetti, Vettakudi and Thenpakkam (Li et al. 2009). In Sri Lanka, Saunders's, Little, Greater Crested and Bridled Terns breed in the Adam's Bridge (Panagoda et al. 2020).

On Rameswaram Island, earlier breeding records of Roseate Tern, Bridled Tern, Lesser Crested Tern, Little Tern (Abdulali 1942), and Greater Crested Tern (Stanford 1937) lacked detailed evidence. This study provides the first comprehensive documentation of breeding colonies of Bridled Tern, Saunder's Tern, Little Tern, Greater Crested Tern and Roseate Tern in the sandbars of Adam's Bridge, Gulf of Mannar (GoM), India.

METHODS

Study Area and Surveys

Raam Sethu, also known in some literature as Adam's Bridge, is a chain of sandbars connecting Rameswaram Island, Tamil Nadu, India, to Sri Lanka, and lies within the Gulf of Mannar Marine Biosphere Reserve. Approximately 8 km south-east of Arichalmunai, near the Sri Lankan maritime boundary, these sandbars (designated I to VII) remain largely isolated due to restricted access. The reserve supports regional endemic breeding species like Hanuman Plover *Charadrius seebohmi* (Byju et al. 2023; Niroshan et al. 2023), rare migratory species Arctic Skua *Stercorarius parasiticus* and Pomarine Skua *Stercorarius pomarinus* (Byju & Raveendran 2022a; Byju et al. 2024) and unusual vagrants like Light-mantled Albatross *Phoebetria palpebrata* (Byju & Raveendran 2022b). Sandbar VII is approximately 2.5 km in length and 1.5 km in width and consists of habitats like sand dunes, and shallow seawater pools. Sand bar III was smaller at 600 m long and 250 m wide (Image 1).

As part of a long-term coastal bird monitoring program, surveys were conducted using boats on all the sandbars except sandbar VII where surveys were conducted on foot due to extensive breeding activity. Surveys on Sandbar VII (9.116 N 79.510 E), from June to August 2024, focused on breeding Greater Crested Terns and other tern species. In total, five teams were formed that consisted of forest personnel and researchers and surveys were conducted simultaneously covering different sections from 0900 h to 1500 h. Breeding populations were estimated using total counts of active nests and direct observations of adult birds within colonies using Nikon binoculars (10 x 50) and Vanguard spotting scopes (14 x 70). The point counts were done in a radius of 100 m each, with each point observed for 15 minutes at randomly selected times as the breeding season coincided with tidal currents not engulfing the sandbar nesting areas on elevated dunes. Aerial (count of the number of birds rising into the air upon our approach) and territory counts (count of the number of nests/adults within colonies) were corroborated with photographs and video recordings to countercheck the estimation process (Surman & Nicholson 2009). The breeding adults did not leave the nests, other than for short periods while disturbed briefly for aerial and territory counts.

Data from Sandbar VII included active nest counts, qualitative description of the microhabitat, and observation of eggs and chicks. Disturbances, such as human activity or predation threats were noted. This

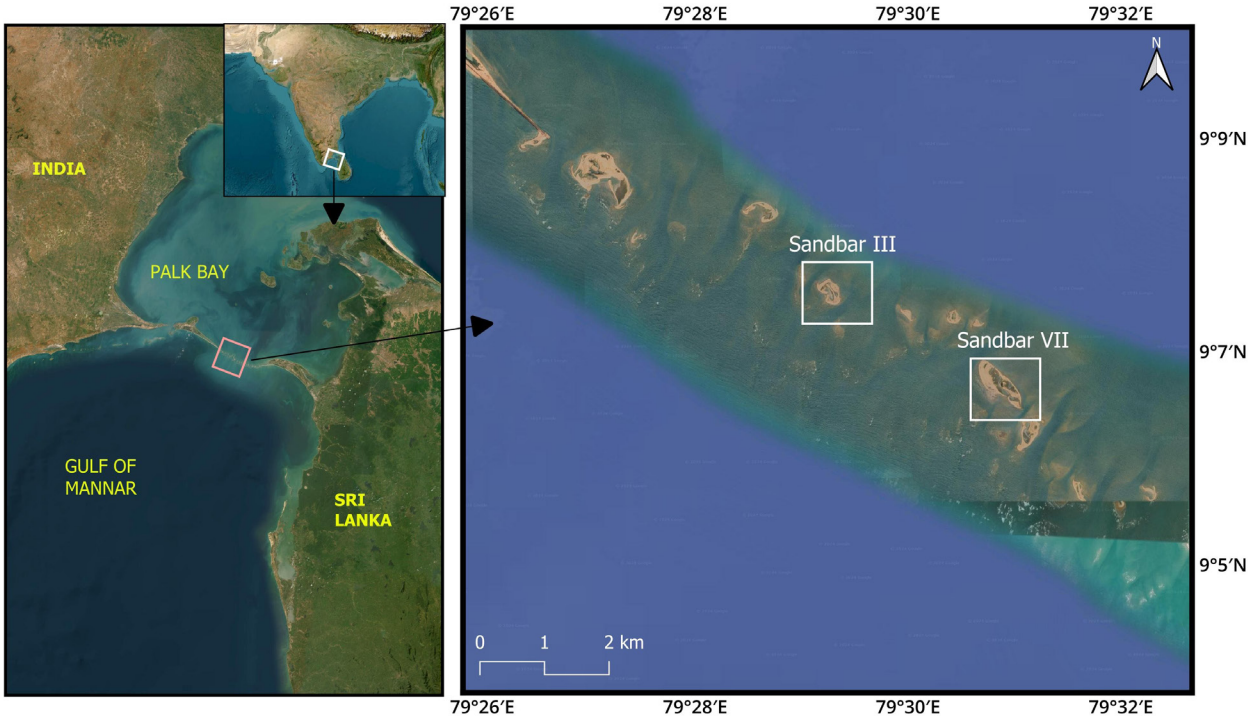

Image 1. Adam's Bridge showing sandbars III and VII as breeding sites.

methodology minimized disturbance while ensuring data collection, providing critical insights into tern breeding ecology in the GoM.

RESULTS AND DISCUSSION

Breeding was confined to sandbars III and VII (Image 1), with Sandbar VII hosting the largest colony of breeding terns. Possibly, the size, water currents and other human disturbances might be the possible reasons of terns avoiding other sandbars for breeding. A total of 16 species of waterbirds was recorded during our surveys (Appendix 1).

Observations from sandbar III and VII

Sandbar III

A colony of 250–300 nests of Greater Crested Tern were found. Little Terns, Brown Noddy (Image 11), and Lesser Noddy (image 12) were observed, even though no other nesting terns could be recorded.

Sandbar VII

Sandbar VII is characterized by sparse vegetation, including grasses (<0.15 m tall), *Sesuvium* and *Ipomea pes-caprae* that cover the sandy beaches where terns nest. Estimated adult tern populations included 12,000 Greater Crested Terns, 600 Bridled Terns, 400 Roseate Terns, 220 Saunder's Terns, and 80 Little Terns, supported by nest counts and photo and videographic evidence (Image 2A).

Greater Crested Tern: An estimated 2,500–3,200 nests were recorded in five different colonies (two major and three minor). Major colonies were approximately 500 m apart, while the minor colonies were separated approximately 200 m from the major colonies (Image 2B). Greater Crested Terns nested densely on elevated barren sand dunes with minimal vegetation (Image 3A) away from other species except for occasional Bridled Terns. Nests were simple depressions, rarely larger (~200 × 170 mm). Most contained one egg (Image 3B), occasionally two. By late July, hundreds of chicks were observed within the colony (Image 3C).

Bridled Tern: Approximately 200–210 nests were found within vegetation as reported earlier (Cramp et al. 1985; Hulsman & Langham 1985; Villard & Bretagnolle 2010), particularly under *Ipomea pes-caprae* and grasses (Image 4A). The vegetation provided shade and protection from predators and other unfavourable physical variables like wind, improving nesting success (Al-Fazari & Victor 2014). The species' nesting habits and habitats align with findings elsewhere (Higgins &

Image 2. A—Sandbar VII | B—Minor colony of Greater Crested Terns.

Davies 1996; Chatto 2001). Nests, typically concealed in the vegetation, contained a single egg (Image 4B), consistent with studies in Australia (Nicholson 2002) and New Caledonia (Villard & Bretagnolle 2010). Chicks were observed in late July (Image 4C).

Roseate Tern: Approximately 150–180 nests were found on the less elevated sand dunes (compared to the Greater Crested Terns) among *Sesuvium* plants with higher nest densities (Image 5A) than Bridled Terns. Nest sites ranged from scrapes with sparse vegetation to exposed concave depressions. Clutches contained 1–4 eggs (Image 5B), consistent with previous studies (Gochfeld et al. 1998). Hatching occurred in early July and the feeding of chicks was observed in late July (Image 5C).

Saunder's Tern: Approximately, 95–105 nests (Image 6A) were found among the *Sesuvium* plants consisting of unlined depressions on sandy ridges shaped by wind. Eggs were sandy in colour with brown blotches and lines (Image 6B). Roseate and Little Terns often nested near each other, with simple scrapes on sandy dunes surrounded by sparse vegetation or marine debris. Egg counts per nest varied between 1–2 and chicks were observed as early July (Image 6C). Nesting habitats, clutch sizes, and egg patterns align with previous studies (Panagoda et al. 2020).

Little Tern: Approximately, 30–35 nests were

Image 3. Greater Crested Tern: A—Birds on elevated sand dunes and eggs in nest depressions | B—Egg | C—Chicks.

recorded (Image 7A), consisting of bare ground scrapes in sand. Clutch sizes ranged 2–3 eggs (Cheah & Ng 2008), with eggs showing olive-green or grey backgrounds and brown spotting (Image 7B) (Wait 1931; Baker 1935; Henry 1998). Chicks were observed in July (Image 7C).

Divergent nest-site selection and ecological requirements among closely related waterbird species breeding in mixed colonies likely serve as adaptive strategies to avoid interspecific competition (Burger & Gochfeld 1988; Chen et al. 2011) as the elevated sand dunes were used by Greater Crested Terns, and

Image 4. Bridled Tern: A—Nesting | B—Egg | C—Adult with the chick.

Image 5. Roseate Tern: A—Incubating adults in higher density | B—Egg and nest | C—Adult with chick.

Bridled Tern nested on the edges with vegetation. On our observations, the major colonies were separated at a farther distance than the minor colonies. For colonial breeders, inter-nest distance may reflect nest-site selection or an anti-predation strategy with larger terns breeding in denser colonies than smaller species as in the case of Greater Crested Terns and other breeding terns (Burger & Gochfeld 1988; Gochfeld & Burger 1996). Intensive nest surveys during peak breeding season revealed the presence of eggs and chicks, although hatching success and the count of chicks could not be determined due to logistical limitations. Sandbars III and VII support an estimated 4,000 breeding tern pairs likely representing the largest mixed breeding colonies in the southern peninsula of India. Their isolation from limited human disturbance makes them critical nesting habitats. However, climate change threatens food resources and population dynamics. For example, a local fisherman informed of the loss of vegetative cover (were in abundance in the past) largely after a major storm that hit a decade ago highlighting the need for long-term monitoring to assess these and several other impacts (Colwell 2010; Hu et al. 2010; Rashiba et al. 2022).

Image 6. Saunder's Tern: A—Adult | B—Egg and nest | C—Egg and nest and chick.

Image 7. Little Tern: A—Adults | B—Egg and nest | C—Chick.

Potential Threats and Conservation measures

We observed several dead bird carcasses from the colonies but could not confirm the reason of death (Images 8 A–C). While human interference is minimal, with rare boat visits to the sandbars by local fishermen, poaching of eggs and sometimes birds were recorded during the surveys. Fishermen or poachers from the Sri Lankan side transgress the Indian sandbar VII to collect eggs and birds using speed boats (Images 9 A&B). Local fishermen of Rameswaram Island also reported consuming tern eggs. Pollution is another threat with sand dunes in the area covered in fishing gear (including nests), plastic bottles, clothes, and household waste (Images 10 A&B). Labels on some of these waste

Image 8. Dead Terns: A—Greater Crested Tern | B—Chick of Roseate Tern | C—Chick of Greater Crested Tern.

Image 9. A—Greater Crested Tern eggs damaged by poachers | B—Poaching from across the border.

Image 10. A & B—Marine debris.

Image 11. Brown Noddy.

Image 12. Lesser Noddy.

materials indicate origins mostly from other parts of southern India, and Sri Lanka. Though hovercraft marks were visible on some sandbars, coast guard hovercraft did not directly threaten tern colonies, as interactions indicated awareness of the breeding areas.

The nesting habitats on Sandbar III and VII, hosting the southern peninsular India's largest colonies of Greater Crested Terns and other tern species, face significant threats from poaching and disturbance. Poachers from across the border and Indian fishermen consume tern eggs. Mitigation efforts should focus on raising awareness and fostering collaboration between the wildlife department and security agencies. Steps have been initiated with security agencies highlighting them with need of not overrunning the nesting populations during breeding time. Conservation measures must also consider the region's sensitivity as an international border, where disputes between the Sri Lankan Navy and Indian fishermen, underscore its importance for biodiversity.

The ecological importance of terns, as well as their sensitivity to environmental perturbations, highlights the need for comprehensive future studies to verify and monitor these breeding populations, particularly given their role as indicators of marine health. Such coastal biodiversity is crucial in maintaining and preserving the ecological integrity and balance within these regions.

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Appendix I. Complete list of seabirds and shorebirds observed around the nesting habitat on the sand bars in the Adam's Bridge.

Common name	Scientific name	IUCN Red List status
Greater Crested Tern	*Thalasseus bergii*	LC
Little Tern	*Sternula albifrons*	LC
Roseate Tern	*Sterna dougallii*	LC
Bridled Tern	*Onychoprion anaethetus*	LC
Lesser Crested Tern	*Thalasseus bengalensis*	LC
Saunder's Tern	*Sternula saundersi*	LC
Sooty Tern	*Onychoprion fuscatus*	LC
Caspian Tern	*Hydroprogne caspia*	LC
Lesser Noddy	*Anous tenuirostris*	LC
Brown Noddy	*Anous stolidus*	LC
Arctic Skua	*Stercorarius parasiticus*	LC
Brown Skua	*Stercorarius antarcticus*	LC
Slender-billed Gull	*Chroicocephalus genei*	LC
Heuglin's Gull	*Larus fuscus heuglini*	LC
Ruddy Turnstone	*Arenaria interpres*	NT
Greater Sand Plover	*Charadrius leschenaulti*	LC
Intermediate Egret	*Ardea intermedia*	LC
Grey Heron	*Ardea cinerea*	LC

LC—Least Concern | NT—Near Threatened.

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The Managing Editor, JoTT,
c/o Wildlife Information Liaison Development Society,
3A2 Varadarajulu Nagar, FCI Road, Ganapathy, Coimbatore,
Tamil Nadu 641006, India
ravi@threatenedtaxa.org & ravi@zooreach.org

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