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Status, Breeding, and Conservation of Black-naped Tern (*Sterna sumatrana*) in the Alphonse Group, Seychelles, 2008–2022

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Abstract.—The Black-naped Tern (*Sterna sumatrana*) breeds throughout the Indian and Western Pacific Oceans. Given the comparative rarity of the *mathewsi* subspecies, a better understanding of its population dynamics is needed. This study aims to improve knowledge of Black-naped Tern breeding ecology and contribute to regional population assessment. Data was collected at the Alphonse Group, Seychelles, where between 2008 and 2022 surveys recorded; abundance of adults, breeding pairs, productivity, location, and seasonality. Counts of maximum adults ranged from 38 to 62 (50.53, SD 7.29), displaying a slight positive trend, while breeding pairs numbered 11 to 28 (16.98, SD 5.04), showing a decrease. Estimates of minimum and maximum productivity were 0.00 to 0.75 (0.23, $n = 21$) and 0.00 to 1.88 (0.49, $n = 21$), respectively, and showed a significant relationship with site and season. Results indicate reproductive success and breeding site preference is becoming increasingly variable. Breeding was temporally widespread, with two discernable peaks in activity in February and June. Changing environmental conditions are the likely cause of breeding pair declines and increasing variability of; inter-annual productivity, breeding onset and site-selection. Findings highlight this species vulnerabilities, the importance of consistent monitoring, and enforced protective measures such as capped visitor numbers and seasonal closure of breeding sites. *Received 24 Nov 2023, accepted 6 Dec 2024.*

Key words.—Black Tern, breeding productivity, Seychelles, *Sterna sumatrana*

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The Black-naped Tern (*Sterna sumatrana*) is a small tern with a tropical Indo-Pacific distribution, breeding from Micronesia in the western Pacific Ocean to the Western Indian Ocean (Gochfeld *et al.* 2020). Throughout its distribution, the species breeds on tropical and sub-tropical islands, foraging for small fish inside atoll lagoons or one to two kilometers offshore (Mizutani and Kohno 2008; Skerrett 2013). Nests consist of a small hollowed out depression in the sand, often amongst coral rubble with a few twigs of material (Diamond and Prŷs-Jones 1986; Skerrett 2013). They are colonial breeders, often in small dense colonies of 5 to 20 pairs, but sometimes numbering a couple of hundred and usually only on islands free from rats and cats (Adam *et al.* 2009). They form monogamous pair-bonds and lay one or two eggs per clutch (Diamond and Prŷs-Jones 1986).

Laying dates are widespread and vary depending on locality, but there is a lack of data on temporal patterns. Incubation is typically shared by the two sexes for 21–23 days. Chicks fledge after 24–28 days of brooding and are thought to receive post-fledging care from parents for at least one month (Diamond and Prŷs-Jones 1986; Thiébot *et al.* 2020). At colonies in Australia, it has been documented that breeding failures were largely caused by flooding of nesting sites and predation of chicks (Hulsman 1977; Hulsman and Smith 1988). In Seychelles, predation by Grey Heron *Ardea cinerea* has been observed on Farquhar and St François (A. Duhec and R. Jeanne, pers. obs.). Furthermore, being territorial, Black-naped Terns are sensitive to anthropogenic disturbance, which can result in desertion and egg or chick abandonment (Carney and Sydeman 1999).

The global population size and trend of the Black-naped Tern is unknown but is not believed to be decreasing rapidly; due to their expansive range, they are currently not considered globally threatened and have been evaluated as 'Least Concern' by the IUCN Red List of Threatened Species (IUCN 2022). The species reaches its western distribution limit in the Western Indian Ocean and Seychelles, where it is represented by the race *mathewsi*, which is

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comparably rare (Gochfeld *et al.* 2020). This subspecies can be found as a vagrant on the East African coast and Madagascar, but is only known to breed in Seychelles, Maldives and the Chagos Islands (Skerrett 2013). Therefore, the Seychelles holds the entire known breeding population for the Afrotropics (Adam *et al.* 2009), estimated at 245–345 pairs (Skerrett 2016). Here, their breeding range excludes the inner islands archipelago, but extends around much of the coastline of the outer islands including Aldabra, African Banks, St Joseph Atoll, Cosmoledo, Providence, St François and Farquhar (Rocamora and Skerrett 2001; Rocamora *et al.* 2003; Rocamora 2013; Skerrett 2013, 2016). The latter atoll is estimated to hold the largest national population at 87–137 pairs (Duhec *et al.* 2017).

Breeding was confirmed at the remote St François Atoll within the Alphonse Group by Adam *et al.* (2009) and this island group, composed of three islands spread across two atolls, was the focus of this study. The colony, of around 16 pairs, is small but significant–making up approximately 5% of the breeding population for Seychelles and exceeding criteria thresholds for the African Important Bird Area (IBA) network, for which the islands of St François have been identified as a candidate for potential IBA status (Rocamora and Skerrett, 2001; Duhec *et al.* 2011). Therefore, scientific monitoring to document their numbers and breeding activity was stipulated in the first Conservation Management Plan (Betts 2009) for the area. The significance of the site, combined with the availability of a longitudinal dataset made this a good study location. Our aim was to improve knowledge of Black-naped Tern breeding ecology, contribute to regional population assessment and promote their conservation.

METHODS

Study Area

The Alphonse Group (7° 0' S, 52° 25' E) is composed of two atolls known as Alphonse and St François, located 400 km south-west of Victoria, Mahé Island, the capital of the Republic of Seychelles (Figure 1). Alphonse Atoll has 402 ha of peripheral reef-flats, a 540 ha central lagoon, and includes the land mass of Alphonse Island, which covers 174 ha. This is the location of a small airport, an eco-friendly hotel, and is the base for a conservation center run by the local non-governmental organization known as Island Conservation Society (ICS), who have employed full-time staff on Alphonse since 2007. St François Atoll is a broad plateau with 732 ha of peripheral reef-flats, a 1,650 ha central lagoon, and three uninhabited islands. Black-naped Terns breed on two of these (Fig. 1)—St François, which is a 30 ha dynamic horse-shoe shaped island with a maximum elevation of 13m (Yamazaki *et al.* 2017), and One Palm island, which is a sand cay of just 5.5 ha (Spencer *et al.* 2009).

On St François, there are mangroves of *Rhizophora mucronata,* and forest dominated by abandoned coconut plantation and casuarina trees. Behind the southern and eastern beach sites where the Black-naped

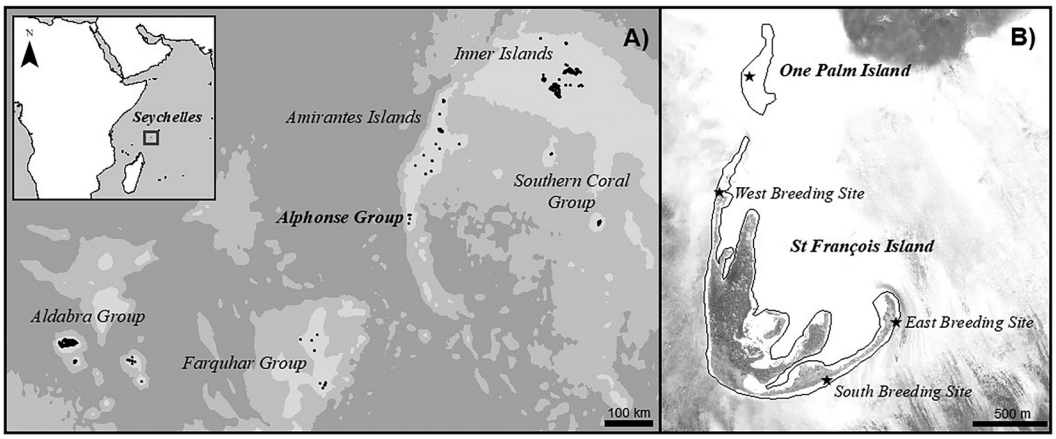

Figure 1. A) The Alphonse Group and other Outer Islands, inset shows the location of Seychelles in the Western Indian Ocean. B) The main Black-naped Tern breeding sites across François and One Palm Islands. Maps created in ArcGIS 10.3 using GEBCO Compilation Group (2020) bathymetry data. Satellite imagery © Island Conservation Society.

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Terns frequently nest is scrubland, primarily made up of *Suriana maritima* and *Scaevola sericea*, with *Tournefortia argentea, Guettarda speciosa* and *Pemphis acidula* (Spencer *et al.* 2009). One Palm Island is largely un-vegetated, with a few scattered coconut trees and grassy patches. The climate is tropical humid and there are two monsoon seasons, named after the prevailing winds: the comparatively wet Northwest, spanning November to April, and the dry but windy Southeast, spanning May to October. Four other seabird species breed on the islands of the Alphonse Group: Wedge-tailed Shearwater *Ardenna pacifica* (150 breeding pairs), Brown Noddy *Anous stolidus* (unknown), Fairy Tern *Gygis alba* (195 pairs) and White-tailed Tropicbird *Phaethon lepturus* (4-6 breeding pairs). There are resident Grey Heron *Ardea cinerea* and Striated Heron *Butorides striatus*. The most abundant non-breeding seabirds and their total counts are: Greater Frigatebird *Fregata minor*, Lesser Frigatebird *Fregata ariel* (4,800–including both species), Red-footed Booby *Sula sula* (20,000), Greater Crested Tern *Thalasseus bergii* (500) and Saunder's Tern *Sternula saundersi* (348). The group also holds good seasonal roosts of non-breeding waterbirds such as Crab Plover *Dromas ardeola* (1,200), Ruddy Turnstone *Arenaria interpres* (450), Whimbrel *Numenius arquata* (200) and Curlew Sandpiper *Calidris ferruginea* (200). All estimates above derived from maximum annual counts collected by ICS staff since the opening of the conservation center (Fordham & Curd, 2023).

Data Collection

We conducted surveys between 2008 and 2022 recording direct counts of adults and any signs of breeding (including nests, eggs and chicks) approximately three times per week on Alphonse Island. Surveys on the islands of St François Atoll were generally less frequent; twice per month throughout the northwest monsoon season, and more sporadic during the southeast monsoon, due to unfavorable sea conditions which make the boat crossing from Alphonse to St François dangerous. Survey frequency was also compounded by capacity and staffing issues during the early years of ICS presence on Alphonse. Here, we summarize data from four sites that were visited regularly: St Francois South, St Francois East, St Francois West, and One Palm Island, as well as one site with only a single recorded observation: Lollipop Shipwreck. Observers made direct counts of the number of adults, nests, eggs and chicks. This was done either by walking through the colony to make a quick assessment (flushing birds off nests was done very briefly, and only in the absence of Grey Herons) or by using binoculars from approximately 30m away. The colonies are dense and small enough that a single recorder with binoculars can see all individuals from one observation point–meaning it is unlikely that active nests were missed during surveys. In some years nests were marked, which made it easier for observers to ensure they were repeatedly monitoring the same broods. However, we noted that individual nests quickly became difficult to track over subsequent surveys due to chicks becoming mobile from an early age and moving around the breeding site (Hulsman and Smith 1988). Additionally, there was concern over the extent to which nest marking drew the attention of predators. Therefore, in many years nest marking was not attempted.

Analysis

Whilst the dataset spanned 2008–2022, we omitted certain years and/or monsoon seasons from analysis where survey frequency was deemed insufficient. To assess their distribution, we exclusively used data from the northwest season, excluding data collected during the southeast, and in the years: 2010, 2011, 2013, 2016, 2018 and 2019, due to low reliability (Supplemental Table S1). We combined the minimum number of breeding pairs observed for all years at each site to calculate total relative usage over the study period.

To investigate seasonality, we characterized chick developmental stages into four categories (Supplemental Figure S1): C1 – small downy chick inside the nest, C2 – partially feathered chick, mobile within the colony, C3 – near fully feathered chick, down remains on the forehead, C4 – fledged chick, still dependent on parents. The C1 stage lasts the first 7 days (Hulsman and Smith 1988) and fledging usually occurs at 26 days (Diamond and Prŷs-Jones 1986; Mizutani and Kohno 2008). Duration of C2 and C3 are not documented, but we assumed a constant growth rate and divided the remaining time equally between these mid-stages as per Hulsman and Smith (1988). We derived egg laying chronology using a mean incubation period of 21 days plus the median value of the below age categories. Black-naped Tern breeding has been observed throughout almost every month of the year, so to prevent biased calculations of productivity, surveys not adequately encompassing the 12 calendar months were excluded (2011, 2012 and 2013). We conducted is. bimodal test, from the R package LaplacesDemon (Statisticat, 2021) and dip.test, from the R package dip.test (Maechler, 2023) to test the bimodality of Black-naped Tern egg laying dates.

We calculated estimates of breeding productivity for all years except 2008, 2012 and 2013 due to insufficient survey frequency. We defined breeding productivity as the number of fledglings per breeding pair, which was calculated for each breeding attempt, and across the entire season. We estimated minimum fledglings, by the number of fledglings observed, and maximum fledglings, including chicks from the previous growth stage i.e. C3. In general, as most mortality of tern chicks occurs in the first week or two after hatching (Nisbet and Drury 1972), we presumed chicks within a week of fledging (i.e. C3) had the potential to evade predation and fledge before the next survey. As the data collected did not meet the assumptions of an ANOVA, we used a Krusal-Wallis test to determine whether productivity was predicted by breeding site, season or year. In years with marked nests (2009, 2014, 2015 and 2016), we estimated the minimum number of pairs by employing the breeding pair estimator method posited by Baasch *et al.* (2015). Baasch et al. made available an excel spreadsheet for researchers to input locally specific dates of key breeding events e.g. first nest observation, last observed activity and when the fate of the nest was determined. This is applied

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alongside user-determined parameters, of the following intervals: incubation, brooding, re-nesting and post-fledging, to determine whether any observations of pairs were duplications. As knowledge on Black-naped Tern re-nesting intervals (following failed or fledged offspring) were absent in the literature, we used the average re-nesting interval of other *Sterna* spp., of 11.5 days, as a proxy (Riechert *et al.* 2013; Wendeln *et al.* 2000). The post-fledging interval was calculated based on post-fledging care lasting up to 31 days plus the re-nest interval, totaling 42.5 days. It is an assumption of this method that selecting longer intervals could lead to a larger pair estimate. This is because as new nests are marked, later in the season, the parameters discussed are used to calculate whether this 'new' nest could belong to the existing pairs. In years where nests were not marked, we used maximum nest or brood counts, to determine the minimum number of breeding pairs. Some observers only reported numbers of eggs and chicks but not nests. In these cases, we divided the number of eggs/chicks by 1.5, the average clutch size for Black-naped Terns (Diamond and Prŷs-Jones 1986).

We assumed breeding pairs could change sites between seasons but remained at one location within a season (pers. obs.). Therefore, when summarizing breeding pairs for a given year, the largest breeding pair estimate of either season was selected.

To assess breeding success (i.e. proportion of nests producing fledglings) all nesting attempts need to be recorded. This requires frequent visits to document each time a clutch is laid and closely monitor the subsequent development and survival of those chicks. Due to our limited number of visits, alternative estimators that account for chicks that fail in between surveys (Mayfield 1961, 1975) could not be used. Moreover, individual nests were normally not marked, and tern chicks tend to gather rapidly into creches where it is impossible to identify which nests they came from.

We summarized maximum counts of adult Black-naped Tern from across the Alphonse Group for all available years i.e. 2008–2022 and fitted a linear regression model to illuminate any significant changes over the study period. To assess the stationarity of adult and breeding populations, we calculated the population growth rate, Lambda (λ). Lambda was computed as the ratio of the population size at the next time step to the population size at the current time step, expressed mathematically as:

$$\lambda = N(t + 1)/N(t)$$

Where $N(t)$ represents the population size at time t.

Visualization of all results and statistical analysis was accomplished using R software, version 3.6.1 (R Development Core Team, 2019).

RESULTS

Distribution

Black-naped Terns were observed breeding at five locations within St François Atoll. The terns were predominantly faithful to St François South, One Palm Island, and St François East, with the total of breeding pairs as follows (shown as percentage of the total number of breeding attempts recorded): St François South, 50.09%; One Palm Island, 34.80%; St François East, 9.56%; and St François West 5.52% (Figure 2). Additionally, there was a single observation in 2011 of two breeding pairs on Lollipop Shipwreck, c. 4km to the South-East of St François, on the eastern outer reef. In earlier years (2008–2012) One Palm Island was utilized most heavily, but subsequently (2015–2018) St François South hosted the most breeding pairs. In recent years site usage appears more dynamic, with 2022 being the first year in the study period where they have formed three sub colonies (Fig. 2).

Seasonality

The breeding season was widespread, and synchronicity of egg laying was low, with pairs observed between the months of January to September (Fig. 3). Two peaks of activity were identified in the months of February and June; however, this pattern of bimodality was not significant (D = 0.11, P = 0.22, n = 12).

Breeding Productivity

Minimum productivity ranged from 0.00 to 0.75 (SD = 0.31 fledglings per pair, n = 21), and maximum productivity ranged from 0.00 to 1.88 (SD = 0.48 fledglings per pair, n = 21; Fig. 4). The lowest annual productivity was 0.00 (2015; 2020) and the highest was 1.88 (2019). Productivity was significantly higher during the southeast monsoon season, compared to the northwest (Kruskal-Wallis Chi squared = 6.16, P = 0.01, df = 1) (Fig. 5 above). There was also a significant difference in productivity between breeding sites (Kruskal-Wallis Chi squared = 6.67, P = 0.04, df = 2) (Fig. 5 below). Productivity ranged across sites: St François South 0.00–1.88 ($\bar{x}$: 0.43, SD = 0.47, n = 12); One Palm Island 0.00–0.60 ($\bar{x}$: 0.30, SD = 0.27, n = 3) and St François East 0.00–1.00 ($\bar{x}$: 0.14, SD = 0.31, n = 6), but there was no detectable trend over the 12 years analyzed (Kruskal-Wallis Chi squared= 10.58, P = 0.48, df = 11).

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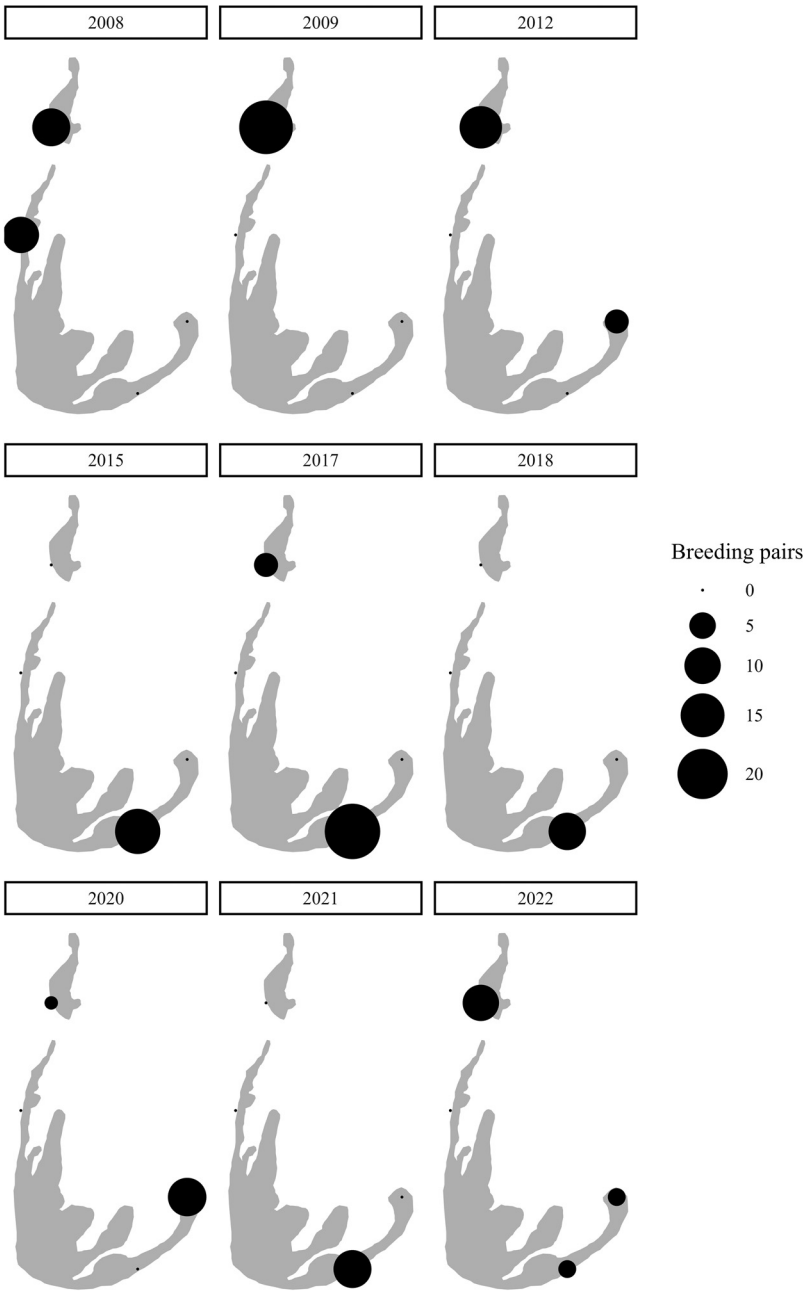

Figure 2. Distribution and number of breeding pairs of Black-naped Terns observed at St François Atoll during the northwest monsoon season.

Population Assessment

The number of maximum Black-naped Tern adults ranged from 38 to 62 ($\bar{x}$ ± SD: 50.53 ± 7.30 individuals; Fig. 6) and displayed a slight increase over the study period, but this was not found to be significant (t = 0.948, P = 0.36, df = 13). Lamba values for adults ranged from 0.71 to 1.46 ($\bar{x}$ ± SD = 1.04 ± 0.06 individuals) (Fig. 7, above). The number of pairs ranged from 11 to 23 ($\bar{x}$ ± SD =16.98 ± 5.04 individuals), showing a statistically significantly decrease (t = −2.41, P = 0.03, df = 12)

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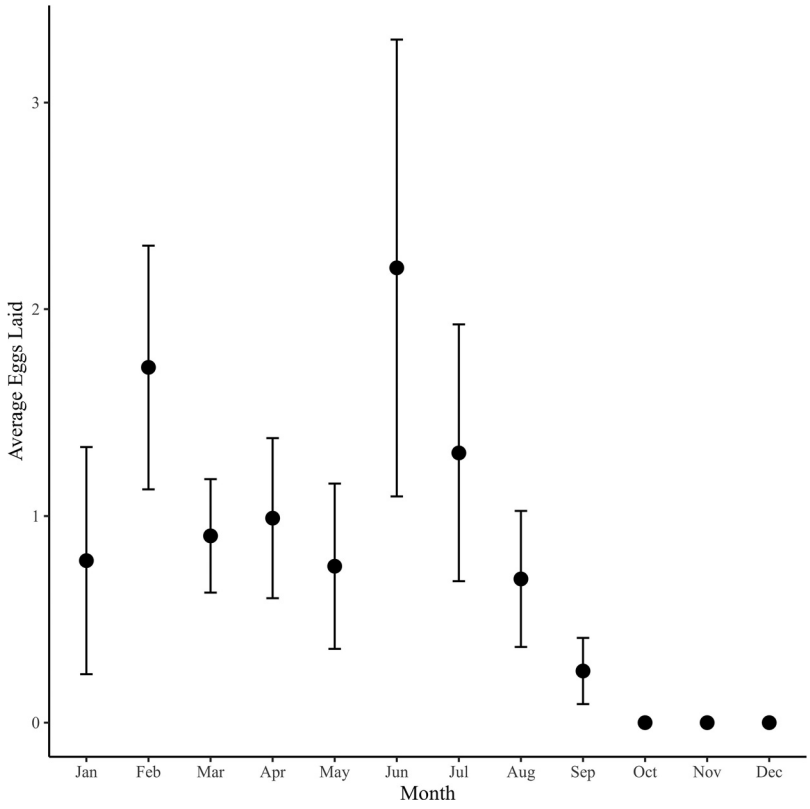

Figure 3. Average numbers of eggs laid by Black-naped Terns for all colonies, per calendar month, as points with error bars displaying SE, across all years (2008–2022), excluding 2011, 2012 and 2013.

(Fig. 6). Lamba values for breeding pairs ranged from 0.57 to 1.39 ($\bar{x} \pm SD = 0.99 \pm 0.06$ individuals; Fig. 7, below).

DISCUSSION

Our analysis is the first to document the breeding ecology of the *mathewsi* sub species in the Western Indian Ocean. We found a slight decline in the number of pairs breeding at St François, which could be linked to some years' where productivity fell to zero. Based on our experience and field notes, we believe these catastrophic breeding failures were triggered by flooding of nesting sites which is likely to become more common in the future as sea levels rise. Our findings demonstrate the importance of collecting data over the long-term and suggest that, although conservation managers may not be able to counteract the drivers of decline which are likely linked to the changing global climate, they must focus on eliminating other growing pressures e.g. human disturbance. The Seychelles, being one of only three countries to support breeding colonies, has an international responsibility to protect them. We urge conservation practitioners in the region to conduct similar studies, to ascertain whether our results are indicative of wider trends, which could lead to joint-up management actions to protect the national population.

Distribution

As the breeding season approaches, Black-naped Terns must decide whether to reoccupy or abandon the former breeding site, and a substantial change in breeding location is a well-documented response of birds to elevated rates of nest predation (Lima 2009). The sudden shift away from the St François South and East sites in 2022, in favor of One Palm Island which had not been used very

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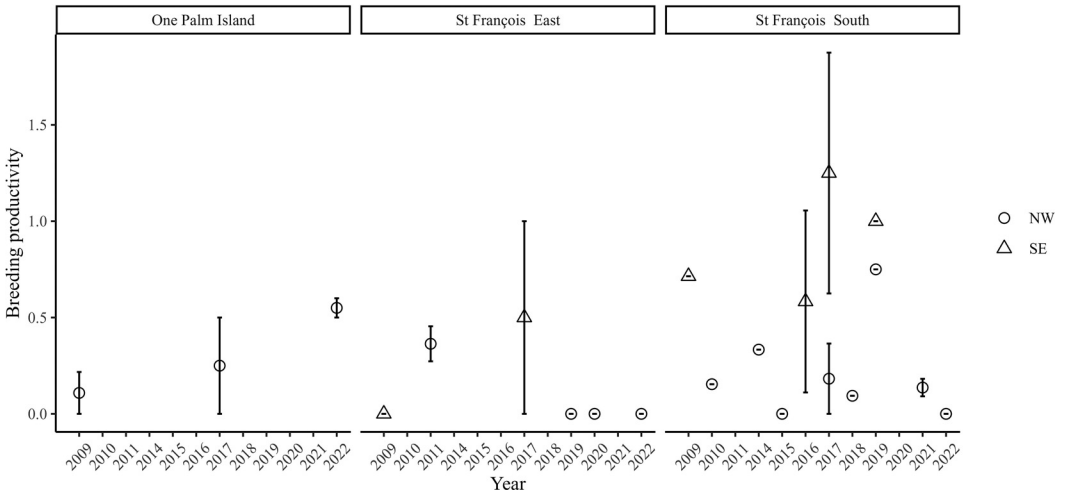

Figure 4. Median breeding productivity (fledglings/pair) of Black-naped Terns across all breeding sites in both the northwest (circles) and the southeast (triangles) monsoon season, with minimum and maximum productivity as error bars.

much since 2012, could be in response to extensive chick and egg mortalities due to flooding in previous years. One Palm Island, which is a largely un-vegetated sand cay, enables them to nest further inland. The trade-off here is there is no habitat for chicks to avoid heat-stress or conceal themselves from predators, and Grey Heron abundance tends to be higher. Little is known about parent decision-making, but their capacity to assess and respond flexibly to risks has been documented (Lima 2009; Thiébot *et al.* 2020). Installation of chick shelters has been shown to have a positive effect on productivity of seabirds including terns by providing artificial cover (Jenks-Jay 1982; Burgess and Morris 1992; Maguire *et al.* 2011). These interventions could be trialed at One Palm Island. The shipwreck where nesting was observed once could not be regularly monitored due to difficult access; however, similar behavior has been previously reported (Hulsman and Smith 1988).

Seasonality

Breeding of Black-naped Terns was temporally widespread at St François, with eggs laid across nine months of the year, a pattern similarly observed at the Farquhar colony in Seychelles (Duhec 2016) and at colonies in the southwestern Pacific Ocean (Benoit and Bretagnolle 2002). However, it differs from the breeding pattern observed at Aldabra, another outer island of Seychelles, where egg laying was found to be more confined to the northwest season (Diamond and Prŷs-Jones 1986). It is notable that there appear to be peaks in breeding activity during both the northwest and southeast monsoons, although this bimodality could not be confirmed statistically.

Breeding Productivity

Our results indicated breeding productivity was highly variable across years, with no discernable trend. Annual assessments of reproductive output give an indication of conditions, in terms of food availability, predator pressure and resistance of nesting sites to environmental or human disturbance (Cook *et al.* 2013). Demographic factors could also be at play; e.g., age-related competence, i.e. the presence of many younger inexperienced adults during certain seasons could explain lower breeding productivity.

The years 2015 and 2020 exhibited the lowest breeding productivity, and field notes indicate failures were associated with spring tides which washed away successive breeding attempts. In 2020, a strong positive Indian Ocean dipole weather event created extra high tides throughout the region, repeatedly flooding all the nesting sites on St François. In the subsequent years, i.e. 2016 and 2021, there was a significant reduction in the maximum

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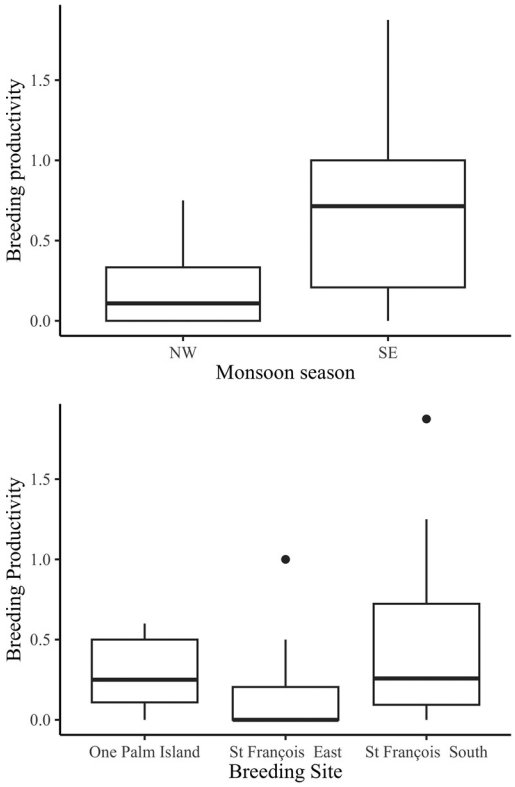

Figure 5. Above - Boxplot showing the distribution of Black-naped Tern breeding productivity across the Northwest (NW) and Southeast (SE) monsoon seasons (Kruskal-Wallis Chi squared = 6.16, *P* = 0.01, *df* = 1). Below - Boxplot showing the distribution of Black-naped Tern breeding productivity across three of the regularly used breeding platforms (One Palm Island, St François East and St François South; Kruskal-Wallis Chi squared = 6.67, *P* = 0.04, *df* = 2).

counts of adults. Furthermore, uniquely in 2016, breeding was heavily delayed, with no pairs observed until the 31st of May (the average date pairs are usually first detected being the 4th of March) which may be linked to greater than average cyclonic activity at the time. Some species forgo breeding entirely if the risk of predation is too high (Lima 2009), and there is evidence that colonies may also respond in this way to severe environmental challenges (Cubaynes *et al.* 2011). Predator pressure is difficult to assess, as it would require a constant observer presence. Nonetheless, opportunistic observations suggest native Grey Heron are key nest predators, and several species of crab are also suspected to prey on chicks.

We found a significant difference in productivity between seasons, with higher rates of success during the southeast monsoon which is characterized by increased wind speeds and a rougher sea state. It has been documented that stronger weather decreases the depth of the thermocline, bringing cold, nutrient rich waters from the benthos closer to the surface, making it easier for deep-water fish to be exploited by seabirds (Spear *et al.* 2001; Sydeman *et al.* 2021). Our findings could be attributed to this phenomenon, however, it is also the case that human visitation to St François is drastically reduced during this season, so pinpointing the relative contribution of different factors to productivity is difficult. St François East was found to have the lowest rates of productivity, which could be related to coastal erosion, which has been documented on this aspect of the island (Fordham & Curd, 2023).

Population Assessment

Despite the number of adults remaining stable, we found a slight decline in breeding pairs between 2008 and 2022. Breeding productivity is known to be highly responsive to changing conditions, whereas breeding pair numbers often follow-suit albeit more slowly, and population level metrics such as maximum counts of adults may not reveal trends of decline until it is too late to mitigate (Cook *et al.* 2013). This observation underscores the importance of monitoring breeding productivity for early warning signs. The reduction in breeding pairs, could be the cumulative reaction of adults to irregular and un-reliable productivity. Some birds might be prompted to migrate to nearby islands in the Amirantes to breed, which then return to the Alphonse Group during their inter-breeding season, which could explain the stability of the adult population.

Limitations and Recommendations

Thanks to financial investment in a program of long-term monitoring, we were able to analyze a significant dataset spanning fifteen years. Although the dataset spanned 2008–2022 we omitted certain years and/or monsoon seasons from analysis where survey frequency was deemed insufficient or inconsistent. This

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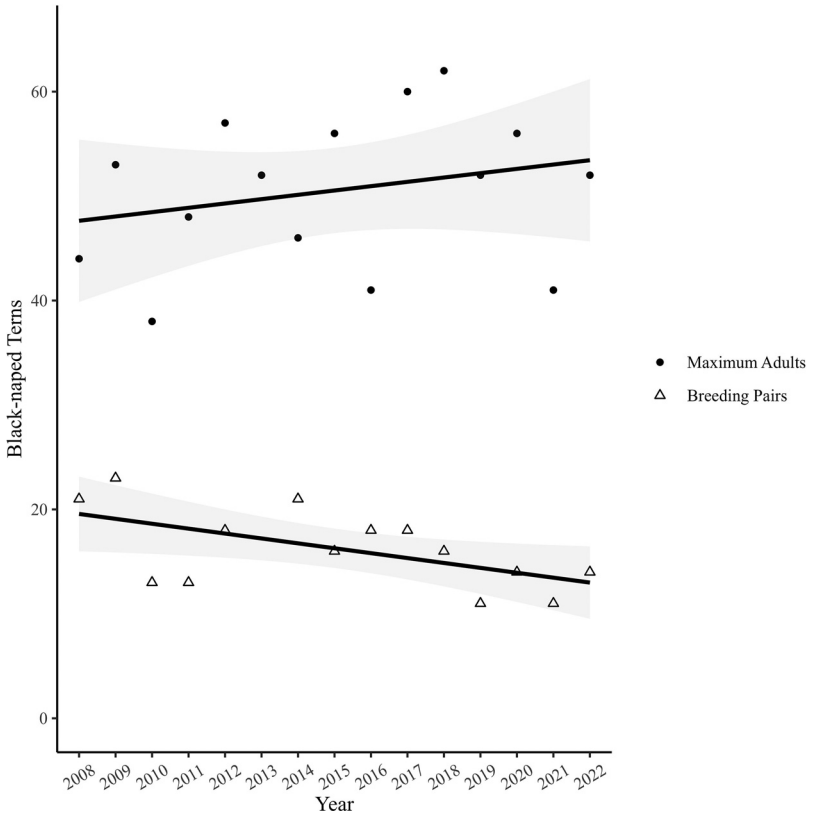

Figure 6. Linear regression of annual maximum counts of adult Black-naped Terns observed throughout the Alphonse Group and minimum number of pairs, with 95% Confidence Intervals.

adjustment was necessary to ensure reliable results. Using discrete data in the form of observations to approximate a continuous process such as nesting activity is challenging. One caveat of our study is that if significant mortality occurs in the first or last week of chick development, reproductive success would be overestimated as mortality would be undetected. Another challenge posed by the tern's asynchronous breeding is our inability to distinguish between younger and older fledged chicks in the dataset. For example, we might have recorded a chick as newly fledged, when it actually fledged earlier in the season and had already been counted.

Continued monitoring will be essential for determining future trends and improved standardization of data collection protocols is needed. We recommend that observers should always record the number of nests, in addition to eggs and chicks' development stages and that the approximate age of fledglings should be recorded by assessing plumage characteristics. New methods of nest marking should be explored and additionally, camera traps could be trialed to help monitor the fate of nesting attempts. Bird ringing could be employed to uncover whether Black-naped Terns have high site fidelity. If conservation staff had capacity to camp overnight on St Francois Atoll, then this could improve accuracy of data. Firstly, multiple counts could be conducted to achieve an average and estimate of error (preferable due to the terns coming and going). Secondly, this would provide the opportunity to identify the timing of peak attendance at colonies. All primary breeding sites should be surveyed consistently to reduce the probability that broods go undetected. Encouragingly, during 2022 conservation staff were assisted to access St François during the southeast season by the local tourism operator who runs larger vessels which can safely make the crossing in rougher sea states. If this cooperative approach is maintained,

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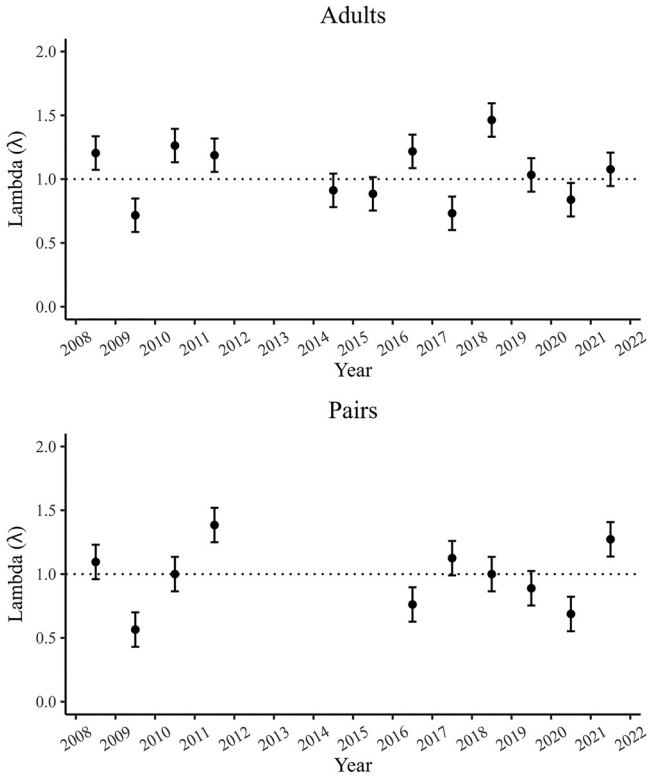

Figure 7. above - Lambda (annual change in adult population) ($\bar{x}$ ± SD: 1.04 ± 0.06 individuals) and below - Lambda (annual change in breeding population) ($\bar{x}$ ± SD: 0.99 ± 0.06 individuals), plotted over time, with a dashed line at 1.0, indication population stationarity.

it will greatly benefit the long-term monitoring of the species.

Gaps in general knowledge of the species' breeding ecology made analysis challenging, such as chick development rates, post-failure or post-fledging re-nesting intervals and the duration of post-fledging parental care. A better understanding of these parameters would enhance our capacity to interpret the data. Additionally, investigating the feeding behavior of this surface feeding seabird, along with the oceanographic parameters that impact prey availability, could improve our knowledge of their conservation needs.

Conservation and Management

Given the race has a particularly restricted range, it is important that population trends are carefully monitored, and data used to inform management actions. St François's Black-naped Terns makes up a significant component of the regional (African) population, therefore, St François deserves to be recognized as an Important Bird Area (IBA), bearing in mind that it also verifies criteria of international importance for non-breeding concentrations of other species of seabirds or waterbirds (e.g. Red-footed Booby, Crab Plover). The decline in breeding pairs and highly variable productivity are cause for concern. Tern species are particularly vulnerable to climate impacts (Moreno and Møller 2011) and the worrying trend we have uncovered might be linked to greater frequency of extreme weather and storm surges. Feeding opportunities for fish eating, surface feeding seabirds are reduced by rising ocean temperatures which disrupt food webs (Sydeman *et al.* 2021). Another potential impact on the conservation of Black-naped Terns in the Alphonse Group is hybridization. In a paralell study, interbreeding has been observed with a Roseate Tern *Sterna dougalli*, which resulted in backcrossing (Fordham *et al.* 2024). Such

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levels of outbreeding can bring negative genetic and adaptive consequences for this small population, although enhancement through heterosis may happen too (Izquierdo-Arànega *et al.*, PREPRINT; Quilodrán et al. 2020; Porretta and Canestrelli 2023).

The Alphonse Foundation brings together a diverse group of stakeholders to raise funds for conservation and agree on research and management priorities. ICS is mandated to carry out this work, and to raise awareness through weekly presentations – in which hotel guests are informed of the importance and sensitivity of sand banks and beaches to nesting seabirds and other wildlife. Disturbance until now has been deemed negligible, however, the Outer Islands are becoming more accessible, and the number of visitors has risen sharply. In recent years tourists from cruise ships were permitted to come ashore to St François Island in large groups, numbering up to 100 people. The risk of disturbance during active breeding periods is high. In the presence of predators, a single disturbance event, especially if prolonged, could be enough to provoke predation which could dramatically impact on breeding success for the whole season.

In 2021 the Government of Seychelles designated the islands of St François Atoll as a Strict Nature Reserve, principally set aside for the protection of biodiversity. We recommend specific consideration is given to the Black-naped Tern colonies in the regulations which are currently being drafted. Measures might include a limit on the number of people permitted ashore at one time, a cap on the number of visits per week and formal temporary closures of breeding sites at the discretion of ICS. Minimizing disturbance may also increase the likelihood that other species begin nesting e.g. Greater Crested Tern. St François is free from invasive species, although ship rats (*Rattus rattus*) are present on neighboring Alphonse Island, so enforcement of biosecurity is critical. Furthermore, eradication of ship rats on Alphonse could facilitate breeding activity, where the species has been known to roost, but not breed.

Our study provides the first assessment of the breeding ecology and population status of a Black-naped Tern colony in the Seychelles. Investigating the seasonality and distribution patterns of Black-naped Terns, we discovered potential flexible modulation of breeding onset and site-selection based on changing risks. We also identified a concerning trend in the number of breeding pairs and conclude that these are likely linked to changing environmental conditions. These findings highlight the vulnerability of the species, and we recommend protective measures including a cap on visitor numbers and closure of breeding sites.

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