Status and trends of White-tailed Tropicbirds *Phaethon lepturus* in the Seychelles.

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**Abstract**

The successful design and implementation of monitoring programmes is an important tool in the effective management of biodiversity, especially in developing nations where resources are scarce and threats are high. We combined monitoring efforts from five of the region’s most vital nesting sites for an indicator species, the white-tailed tropicbirds *Phaethon lepturus*.We present the first regional summary on the level and trends of breeding success at each of the sites; at Aldabra atoll on average 15.2% of nests were successful compared with 33% on Cousin Island, 40.2% on Aride Island, 51.6% on Cousine Island and 55% on Denis Island. In addition, at Aldabra there was a significant negative temporal trend in breeding success observed. The Aride Island population showed a continuous negative trend in nest density, whereas the Cousine island nest density increased. Disparity in methods, duration and longevity of the programmes prevented direct statistical comparisons between sites. It was not possible to determine causes of trends, though the regional outlook enabled some interpretation of the potential drivers of change at site level. Recommendations are therefore made to improve the effectiveness of these conservation efforts and streamline the monitoring programmes for *P. lepturus* across the Seychelles.

Keywords: Seychelles, Tropicbirds, Management, Ecology, Breeding

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**Introduction**

The Western Indian Ocean has recently been identified as a key area to prioritize for the conservation of global marine biodiversity in the face of climate change (Ramírez et al. 2017). With 115 islands stretching across an exclusive economic zone of 3.2 million km2 the Seychelles is a challenging location for articulated monitoring efforts. Monitoring programmes are widespread across the Seychelles islands and if successfully designed and implemented they have potential to form an integral role in informing conservation management. However, poorly designed monitoring programmes or lack of institutional capacity often result in data piling up. Without rigorous and regular analysis programmes are unable to fulfil their original aims—delivering information on trends in key aspects of biodiversity, providing early warning of problems, generating evidence of conservation success or failure and highlighting ways to make management more effective (Lindenmayer et al. 2012).

Indicator species whose status reflects or predicts the condition(s) of the broader environment are often the focus of monitoring efforts. Seabirds possess several attributes that make them useful as environmental indicators (Bost & Maho, 1993), as they provide both a measure of health of the species as well as an indication of overall state of the surrounding ecosystem (Parsons et al. 2008; Piatt et al. 2007). The Seychelles supports the greatest abundance of tropical seabirds in the Indian Ocean, estimated to be ca 3.4 million pairs (le Corre et al. 2012). It is the main breeding ground for White-tailed Tropicbirds (*Phaethon lepturus)* with anestimated 56% of the Western Indian Ocean breeding population (le Corre et al. 2012).

*P. lepturus* is a pelagic seabird that undertakes long foraging trips and feeds mainly on surface-dwelling prey, such as flying fish and squid (Schreiber & Clapp 1987). This specificity of their foraging strategy limits their rate of provisioning when these particular food sources are scarce (Schaffner, 1990) and the scarcity of these food sources indicates changes in lower trophic levels. Additionally, *P. lepturus* is ground nesting (Burger and Lawrence 2000) and therefore nesting success is highly susceptible to habitat integrity and environmental perturbations such as climatic variations (Ancona et al. 2011) and invasive alien species (Russel and Le Corre, 2009).Determining trends in this indicator species at a regional scale is a required first step for effective management of this species as well as providing managers with an early warning system of broader scale environmental changes.

Although *P. lepturus* is listed as ‘Least Concern’ on the IUCN red list, the species is suspected to be in decline owing to predation by invasive species at nesting sites (IUCN Red List). As a pelagic species with large home ranges, monitoring of a single location is often not enough to assess regional trends. Fortunately, monitoring of *P. lepturus* breeding success has been conducted on a number of Seychelles islands. However, despite the monitoring programmes in place across the Seychelles, the regional conservation status of *P. lepturus* is unknown. Neither is it clear whether the monitoring programmes in place are adequate to answer the questions of population and breeding status or broader environmental change.

Here, for the first time, we compile regional multi-island data to determine the conservation status of *P. lepturus* in the Seychelles. Our primary objectives are to: (1) identify trends in breeding success across sites; (2) where possible assess trends in nesting density across sites; (3) where possible identify trends in breeding seasonality across sites; and (4) determine the extent to which the current monitoring programme methods enable *P.lepturus* to be used as environmental indicators. Lastly, we aim to use these results to suggest changes to monitoring programmes for *P. lepturus* across the Seychelles to ensure monitoring efforts fulfil research aims, and to allow direct comparability between sites.

**Material and methods**

**Study Sites**

We analysed data available from five islands in the Seychelles: Aldabra Atoll, Aride Island, Cousin Island, Cousine Island, and Denis Island (Figure 1). These sites cover the main breeding sites in Seychelles for *P.lepturus* (Aldabra, Cousin, Cousine & Aride) as well as Denis island, of which little is known about the *P.lepturus* population. The sites vary in size, geomorphology, elevation, protected status, management types, predator threats and estimated *P. lepturus* population size (Table 1). Although other islands also have *P. lepturus* breeding populations, most are un-monitored.

All the monitoring programmes were developed separately and despite being based on the guidelines developed by a local NGO in the “Seabird monitoring handbook for Seychelles” (ref, date), guidelines are limited to a description of the methods to obtain breeding success data, and not specifically how to set up a long-term monitoring programme. The studies varied in area covered, monitoring duration, frequency, methods and monitoring area habitat type (Table 2).

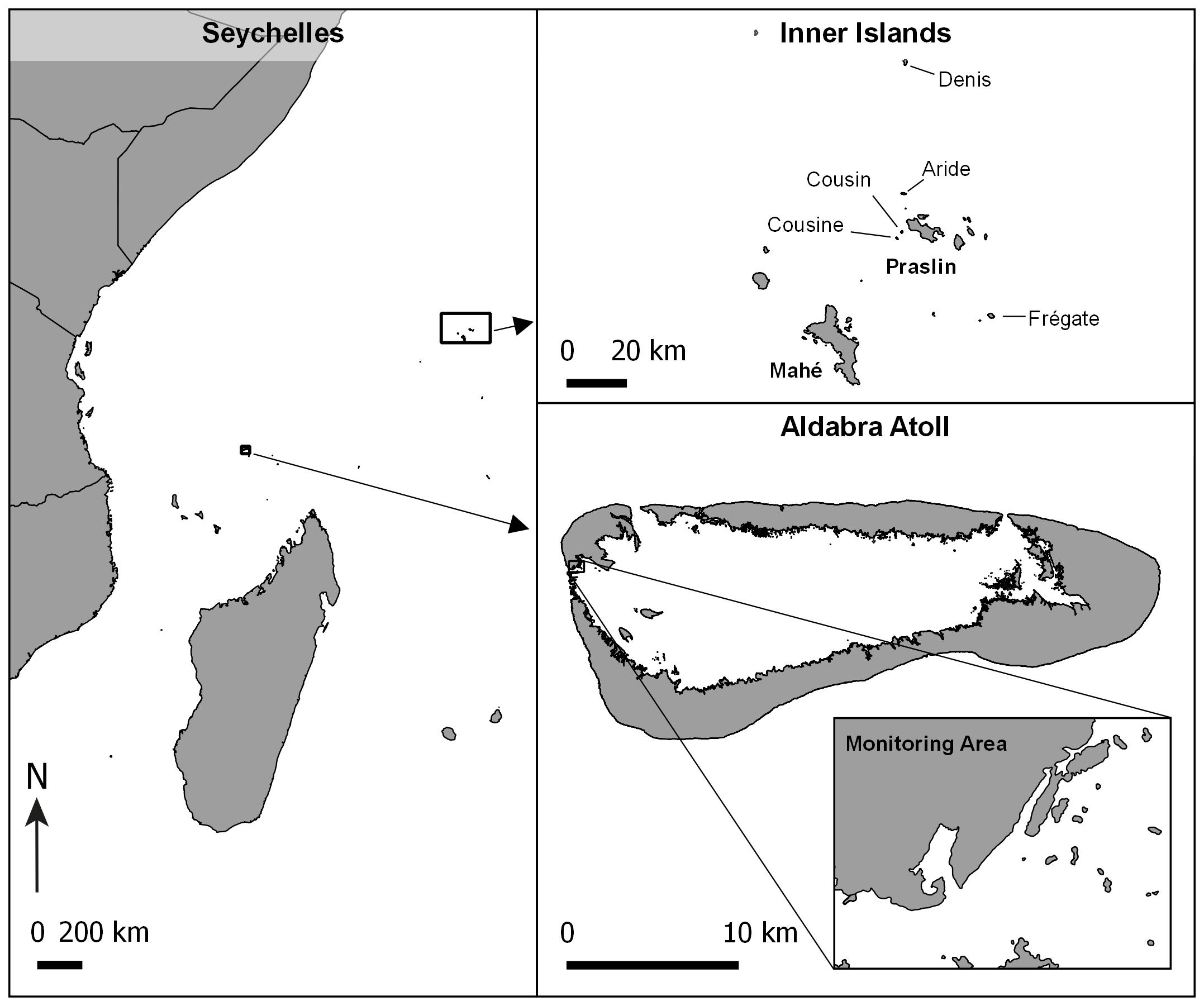


Figure 1: Map of showing location of Seychelles and the five monitoring site locations.

Table 1: Details of the five study locations.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Island** | **Protection status** | **Land area (ha)** | **Geomor-phology** | **Location** | **Max height asl (m)** | **Management** | **Population estimates** | **Nest predators** | **Other Disruptive\* species** |
| Aldabra Atoll | UNESCO World Heritage site (1982); Special Reserve (1975) | 15,254 | Coralline | 9.2255**°**S,  46.1310**°**E | 8 | Public Trust | 2000 pairs 1 | Black rat*,* grey heron, Aldabra drongo4  Coconut crab1 | Red-tailed tropicbirds4 |
| Aride | Special Reserve (1975) | 74 | Granitic | 4.2000**°**S, 55.6667**°**E | 134 | NGO | 1,446 pairs 2 | Seychelles skink, wright’s skink and Seychelles fody5 | *Pisonia grandis* 4 (bird-catcher tree), big headed ants4 (until 2016), ticks. |
| Cousin | IUCN class 1A Special Reserve (1975) | 27 | Granitic | 4.3314**°**S, 55.6631**°**E | 69 | NGO | 2110 pairs 3 | Seychelles skink, wright’s skink and Seychelles fody, ghost crabs6 | *Pisonia grandis*4 |
| Cousine | Privately owned | 26 | Granitic | 4.3500**°**S, 55.6333**°**E | 72 | Private | 450–850 pairs8 | Seychelles skink, wright’s skink and Seychelles fody, ghost crabs 7, Seychelles magpie-robin5. | *Pisonia grandis*4,giant tortoise5*,* big- headed ants4. |
| Denis | Privately owned | 140 | Sand cay | 3.8000**°**S, 55.6667**°**E | <4 | Private | ca. 40 pairs (this study) | None perceived, cats removed in 2000, rats removed in 2002. |  |
| 1Diamond 1971, 2Burger and Lawrence 2000, 3Bowler et al. 2002, 4Recorded but unpublished, 5Observed but unpublished, 6Phillips 1987,  7Malan et al. 2010, 8Skerrett et al. 2001, \*Observed to or thought to hinder breeding success by increasing nest desertion or causing parent mortality. | | | | | | | | | |

**Monitoring nesting success**

For all five islands, nesting *P. lepturus* were defined as an adult with an egg or a chick on a nest. Nests were checked (and new nests searched for) between every 2–3 days and every two weeks, depending on the island (see Table 2). To determine nest outcome, the stage at which the nest was last observed active was recorded. If a nest was observed to have been occupied by an egg or a young (partially feathered) chick and it was subsequently observed empty or with signs of predation/death on the succeeding visit, it was assumed that the nest had failed. If a nest was observed to be occupied by a fully feathered chick and then found empty in the subsequent visit without signs of predation/death, it was assumed that fledging had occurred and therefore that the nest was successful (hereafter breeding success). For those sites that monitored all nests within a specific area (Aride, Aldabra, Cousine) the number of nests is hereafter referred to as nesting density and is used as a proxy for breeding population size. New nesting attempts were only included in the dataset when the attempt was at the egg incubation stage to avoid including nesting attempts that had already successfully reached chick stage. Each nesting attempt was characterised by the date of the first record, and whether the attempt resulted in a successful fledged chick or not. If the nest was unsuccessful we also recorded whether failure occurred at the egg or at the chick stage.

Table 2. Details of the five *P*.*lepturus* monitoring programmes including the last assessment conducted of breeding success.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Island** | **Area monitored (ha)** | **Dates of data collection** | **Frequency of monitoring** | **Methods** | **Nest Distribution** | **Nest Habitat Type** | **Last assessment** |
| Aldabra Atoll | ?? | Feb 2009– Nov 2016 | Continuous year-round monitoring, every 2 weeks | The entire monitoring area was searched and all new nests recorded and tagged. These nests were visited on subsequent surveys until nest outcome was determined. | Only on lime stone islets or coastal outcrops. Only monitored on 13 lagoon islets and an outcrop of Picard Island. | Lime stone cavities or cavities in dense vegetation on small islets and coastal outcrops. | Prys-Jones et al. 1980 |
| Cousin Island | 20 | 2005–2007, 2009–2016 | Once/twice a year beginning in Feb and/or July | The survey effort was defined by a set number of nests rather than a specific area. Approximately 100 nests at incubation stage were tagged. These nests were visited on subsequent surveys until nest outcome was determined. | Ubiquitous though predominantly monitored on the plateau both along the coast and inland. | Bare scratched patches inside rock or log cavities or against tree roots or boulders. | Phillips, 1987 |
| Aride Island | 5 | Jan 2011– Dec 2016 | Continuous year-round weekly monitoring | The entire monitoring area was searched and all new nests recorded and tagged. These nests were visited on subsequent surveys until nest outcome was determined. | Ubiquitous though only monitored on coastal plateau along coastal and inland areas of forest. | Bare scratched patches inside rock or log cavities or against tree roots or boulders. | Ramos et al. 2005 |
| Cousine Island | James?? | Jan 2007– Dec 2011 | Continuous year-round weekly monitoring | 90 nest sites were monitored continuously. Each new nest was tagged and visited on subsequent surveys until nest outcome was determined. | Ubiquitous though only monitored on accessible eastern side. | Bare scratched patches inside rock or log cavities or against tree roots or boulders. | Malan et al, 2010 (data from 2003–2005) |
| Denis Island | Ca 65 | Nov 2015–Sept 2016 | Continuous year-round monitoring, every 2 weeks | The entire monitoring area was searched and all new nests recorded and tagged. These nests were visited on subsequent surveys until nest outcome was determined. | Ubiquitous though more abundant in forest. Monitored in all areas except the coconut plantation. | Mostly in trees cavities or on forked branches/trunks as well as on ground amongst tree roots or boulders. | NA |

**Data analysis**

We analysed overall breeding success, and temporal trends in breeding success and nesting density wherever possible. However, due to differences in data collection methods, duration, and age of the monitoring programmes, we were unable to compare breeding success directly between monitoring sites.

We explored temporal trends for Aldabra, Aride, and Cousine, where monitoring takes place continuously over the years and surveys span several years. To do that, we employed a set of Generalised Additive Models (GAM) in each location with nest density or breeding success as a response variable. Nest density was defined as the number of new nests recorded within the monitoring area per month while breeding success was fitted as a binomial variable (nest fledged = 1; nest failed = 0). We employed a normal and binomial error structure for the density and success models respectively. We included two independent variables as smooth terms,, ‘date’ and ‘month’ in order to assess long term trends while accounting for the possible seasonality in the response variables. Survey effort was constant over the year in all these tree locations, and as we are not performing comparisons across sites it was not necessary to account for potential sources of variation among the areas surveyed.

Data for Cousin and Denis Islands were insufficient to perform this analysis and therefore only annual average breeding success was included for these sites. Cousin data was collected using a selection of nests chosen at one point in the year and this selection was followed until all outcomes were accounted for, no additional nests were added. Also, in Cousin, the number of nests monitored was not constrained by survey area; simply a sample of nests were chosen. The Denis Island monitoring programme was in-place for just under one full year. Whilst not comprehensive, the data obtained from these sites was sufficient to obtain a general indication of breeding success. In any case, evaluating the differences in methods is also a key aim of this study and we therefore take this up in the discussion.

**Results**

We observed variation in breeding success (% of successful nests) between monitoring sites. Success was highest at Denis Island followed closely by Cousine Island and was lowest at Aldabra Atoll (Table 3). The relative proportion of nests that fail at the egg or chick stage, however, did not vary greatly between sites. Breeding success remained constant over the years in which monitoring was carried out on all islands except Aldabra, where a significant decreasing trend was observed (df=1, x2=7.61, p=<0.05; Fig 2A; Table 4).

Table 3. Number of *P. lepturus* nests monitored in study period, overall nesting success (% successful nests, i.e. fledglings) and the proportion of nests that failed at egg or chick stage at each site (%).

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Island** | **Total nests monitored** | **Annual mean # nests monitored** | **Annual mean # nests successful (fledged)** | **(%) of failed nests failed at egg/chick stage** | **Annual mean nesting success (± SE)** |
| Aldabra Atoll | 333 | 42 | 6.4 | 66 / 34 | 15.2% (± 2.29) |
| Aride | 1033 | 172 | 69 | 62/38 | 40.2% (± 3.8) |
| Cousin | 854 | 93 | 37 | 64/36 | 33% (± 4.04) |
| Cousine | 537 | 107 | 52.2 | 72/28 | 51.6% (± 2.9) |
| Denis | 39 | --- | --- | 61/39 | 55%\* (± 9.3) |
| \* Mean monthly success | | | | | |

In Aldabra, there was no significant temporal variation in nesting density (the number of new nesting attempts recorded per year). However, we observed a significant decline in nesting density in Aride (df=1.6, x2=35.2, p=<0.05; Fig 2B; Table 4) and an increase in Cousine (df=1.9, x2=29.2, p=<0.05; Fig 2A; Table 4). On Aride nesting density showed a seasonal pattern with a peak in nesting attempts during September and October, a secondary peak between April and June and a low in December and January (df= 3.8, x2=49.1, p=<0.05; Fig 3; Table 4). Seasonality in nest density is present though weaker on Cousine (df= 3.1, x2=12.7, p=<0.05; Fig 3; Table 4) and virtually nonexistent on Aldabra.

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***Figure 2:*** *Long-term trends in (A) Nesting density of new P. lepturus and (B) probability of nesting success on five islands in Seychelles. Shaded areas indicate the corresponding standard error of the model predictions. Vertical bars indicate standard deviation for Denis island.*



***Figure 3:*** *Seasonality in nesting density of P. lepturus. Shaded areas indicate the standard error of the model predictions.*

***Table 4:*** *Generalised additive model output for nesting density and breeding success. Trend refers to temporal change and season refers to changes observed on an annual cycle (seasonality).*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Model** | **Island** | **Term** | **e.d.f.** | **χ2** | ***p*** |
| success | Aldabra | trend | 1.00 | 7.61 | 0.006 |
| Aride | trend | 1.00 | 0.14 | 0.706 |
| Cousine | trend | 1.00 | 0.06 | 0.802 |
| nests | Aldabra | season | 0.64 | 1.17 | 0.151 |
| trend | 2.11 | 5.68 | 0.090 |
| Aride | season | 3.78 | 49.1 | 0.000 |
| trend | 1.60 | 35.2 | 0.000 |
| Cousine | season | 3.09 | 12.7 | 0.003 |
| trend | 1.99 | 9.25 | 0.014 |

**Discussion**

**The answer to the study question (status and trends)**

This study provides the first evidence to support a national conservation status for *P. lepturus* within the Seychelles. The results show an overall stable trend in breeding success in the granitic Seychelles (Aride, Cousine and Cousin) but a decline in the breeding success at Aldabra. Nesting density at all three sites differed. In Aride nesting density was in decline, Aldabra was stable and Cousine was increasing. The differences across sites and methodologies do not allow us to infer national or regional population status. Improved monitoring across Seychelles and other important breeding sites across the Western Indian Ocean (Europa Island, Mauritius, Reunion, Rodriguez, Comores and Madagascar (Le Corre et al, 2008) are likely to be necessary for such a enterprise. Our study therefore represents just one piece of the puzzle, albeit a significant one . We acknowledge and wish to highlight the issues which prevented a more robust conclusion and discuss the extent to which the current methods enable *P. lepturus* to be used as an indicator of broader environmental changes.

**What the results tell us about the monitoring programmes**

Within the Western Indian Ocean and outside of the Seychelles, there is currently only data published on the Europa Island *P. lepturus* population. There, breeding success has been recorded at 6.9% (Ringler, et al., 2015) though no trend data is currently available. Throughout their range *P. lepturus* breeding success is highly impacted by predation of invasive predators (e.g rats; Russel & La Corre 2009; Sarmento et al., 2014) with regional populations being categorized ‘Endangered’ as a result (Christmas Island & Eastern Indian Ocean, Garnett, 2010; Brazil, Leal et al. 2016 & Campos et al. 2017). Aldabra is the only site in this study with invasive predators lends support to this claim but based on the current data available, attributing a decline in breeding success at Aldabra to rats is not possible. Of all the known and potential predators listed for Aldabra, all except rats are also monitored, however none have shown increasing trends (SIF unpublished data). This additional data is very valuable but to enable *P. lepturus* to be truly used as indicators of broader environmental conditions it is necessary to quantitatively account for any influence invasive predators have on breeding success and population size. It should be a primary consideration when setting up monitoring programmes for indicator species and unless the research aims specifically to account for the presence of invasive predators and other nest site specific factors it is perhaps better to forego monitoring or abandon the objective of monitoring the broader environment.

The Denis Island monitoring programme lacked longevity which reduced the value of the data obtained, likewise the Cousine data ceased in 2011 making direct comparison between sites impossible. This highlights a common issue impacting the success of long-term monitoring programmes within Seychelles but also across the globe; the loss of key personnel or rather the lack of institutional/organisational support to ensure continuity despite changing staff. The Cousin Island data established a basic stable trend with breeding success averaging 33% in this study compared to the 36% recorded by Phillips in 1987. The data was amongst the most consistent in terms of duration of monitoring but due to the different methods and frequency of monitoring at this site it was not possible to determine anything beyond an estimate of breeding success at one point in the year and therefore breeding success could not be directly compared to other sites. As the method also didn’t include nesting density data collection this monitoring programme could not be used to estimate breeding population trends. However, Cousin, Cousine and Aride do all conduct annual seabird census, which provide population trend data. By including density into the breeding success monitoring it can reduce the necessity for census or rather reinforce trends found in census data.

The continuous negative trend in nesting density found on Aride was previously reported; Bowler et al. (2002) showed that the nesting population of *P. lepturus* suffered an apparent decline of 60% between 1989 and 1998, and our results and unpublished census data also support the continuation of this decline. There are two key factors that suggest population decline on Aride is caused by adult survival at the site; firstly, that Aride continues to maintain relatively high and stable breeding success and secondly, that neighbouring island Cousin maintains a stable population trend (1987 to 2014, unpublished census data) and Cousine island shows an increasing population trend (this study and 2003 to 2017 unpublished census data). For these islands that are within close geographical proximity it is reasonable to expect *P. lepturus* to be under similar influence of external factors (climatic variations and food availability) indicating that the Aride breeding population decline is not linked with external factors. Additional work by Catry et al (2009) determined that annual adult survival could not be linked to inter-annual variability in oceanographic conditions, but may be more influenced by *Pisonia grandis* fruiting events, which, overall, accounts for 23.2% of the adult mortality. *P.grandis* is native to Seychelles and thrives in acidic guano enriched soils, It produces sticky seeds which can trap and kill seabirds and is common across Aride, Cousin and Cousine. The results found by Bowler et al. (2002) and Catry et al, (2009) as well as the results from this study demonstrate the necessity of adaptive management into this monitoring programme. In the 2017 Aride management plan a clearance of 1.5 Ha of *P. grandis* is planned to tackle the seabird entanglement issue (Calabrese 2017). If during the first year the areas are successfully cleared and maintained, the clearing effort will be increased in targeted areas for *P. lepturus*. Monitoring of *P. lepturus* will continue in order to assess the effectiveness of *P. grandis* removal on the breeding population.

***Monitoring Programmes***

In order to build upon current knowledge and efforts and improve the value of data for *P.lepturus* throughout the Seychelles werecommend anationwide monitoring plan should be implemented with consideration for the spectrum of resources available at each site. The major characteristics of effective monitoring programs typically include carefully posed questions and objectives and a conceptual model of the ecosystem or population (Lindenmayer & Likens, 2010). The following recommendations are made for the Seychelles *P. lepturus* monitoring programmes:

1. To enable national level monitoring of *P. lepturus* a standardised protocol should be developed and ideally followed at all sites, coupled with a standard database format to ensure data management enables and leads to frequent analysis. The protocol should outline the conceptual model and the specific objective and aims of the monitoring programme (Reynolds et al, 2017).
2. Based on the limitations found in the current study we propose a year-round continuous long-term monitoring of a designated area (with consideration for accessibility for regular monitoring and representative of typical nesting habitat). The area must be large enough to include a sample size of minimum 30 nests per year. This will ensure the data from each site are directly comparable. Monitoring of the area should be conducted a minimum of once every two weeks (though ideally once weekly to) to ensure: i) that the number of new nests which fail in early stages are captured as much as possible and ii) to endeavour to correctly record the stage at which nesting attempts failed and iii) that the nests are not unduly disturbed by frequent human presence.
3. Additional parameters may be included that do not increase time or personnel required though will be greatly beneficial in future analysis to eliminate or highlight certain factors should a decline be observed. These may include a measure of nest site choice; for tropical seabird species nest microhabitats and behavioural thermoregulation, are important factors during egg brooding and early chick development (Hart et al, 2017). Nest site choice can be recorded in terms of habitat type (e.g vegetation/rock crevice/tree limb etc) and site exposure (e.g level of shade, peripheral cover from weather and accessibility to predators). Secondly the monitoring can include recording evidence or observation of predator interaction.
4. Any additional programmes that monitor the ecosystem that *P. lepturus* individuals interact with (identified in the conceptual model) are beneficial. This more integrated ecosystem approach will not only assess changes but may also deliver evidence of underlying reasons for observed changes (Kupschus et al. 2016). For example, monitoring trends in natural or invasive predators, vegetation phenology and climate variables.
5. Should a declining trend be observed then further actions may be taken to determine cause, these may include the use of camera traps on nests to observe factors such as predation, chick feeding frequency and nest desertion by adult (Rendall et al, 2014). If there is no obvious cause then further investigation of external factors such as climate and food availability may be investigated via satellite data coupled with geo-tagging birds (Campos et al, 2017; Le Corre et al, 2012).

*Conclusions*

The Western Indian Ocean has recently been identified as a key area to prioritize for the conservation of global marine biodiversity in the face of climate change (Ramírez et al. 2017). The Seychelles Archipelago supports the greatest abundance of seabirds in the tropical Indian Ocean (Le Corre et al, 2012). Regional seabird population success and trend data is not readily available despite data being collected for many years at several locations. A greater effort must be made to streamline regional data and utilise the results to steer management practices and channel research resources towards the most critical areas. This study highlights a decline in nesting success at Aldabra atoll and a decline in nest abundance at Aride, both require further understanding and therefore management should focus research efforts and conservation resources at establishing likely causes of these declines. This is likely to be most successful by establishing an ecosystem approach to monitoring and implementing adaptive management across the region.

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**Supplementary Material**

Additional Island Information

*Aldabra Atoll*

Aldabra Atoll is a raised coral atoll, approximately 1150km southwest of the main Seychelles island of Mahé (Figure 1), and consists of four main islands totalling 155 km2 area around a central 195.9 km2 lagoon. *P. lepturus* nest predominantly on islets within the lagoon. The habitat of the islets (area between 41 and 570 m² (mean 249 m²) consists of pitted limestone crevices and salt tolerant vegetation with varying degrees of coverage.

*Aride Island*

Aride is the northernmost granitic island of the Seychelles Archipelago and is situated 15 km away from Cousin Island and 50 km from the main island of Mahé (Figure 1). Aride’s 74 ha consist of 5 ha of flat plateau and 69 ha of mountainous terrain. The island has been restored from a degraded coconut plantation. A colony of *P. lepturus* nests across the island but monitoring is consistently conducted on the plateau along coastal and inland areas of forest.

*Cousin Island*

Cousin is 2 km from Cousine Island and 35km from the main island of Mahé (Figure 1). Cousin’s 27 ha consist of 21.6 ha of flat plateau and 5.4 ha of mountainous terrain. The island has been restored from a degraded coconut plantation. A colony of *P. lepturus* nests throughout this habitat but are predominantly monitored on the plateau both along the coast and inland.

*Cousine Island*

Cousine Island, 2 km west of Cousin and 32 km NE of the main island of Mahé (Figure 1). The island is close in proximity, size and habitat to Cousin Island and likewise has been restored from a degraded coconut plantation. A colony of *P. lepturus* breeds across the island but monitoring has concentrated throughout the accessible plateau on the eastern side.

*Denis Island*

Denis Island is ca. 43 km north of Aride Island and 80 km north-east of the main island of Mahé (Figure 1). Denis holds a small population of *P. lepturus* which nest across the island.