Population, distribution and feeding preferences of the Seychelles Fruit Bat *Pteropus seychellensis* on Aride Island

Rory Crawford

**Introduction**

The Seychelles has only two native land mammals, both of which are bats and are endemic; the Sheath-tailed Bat, *Coleura seychellensis* and the Seychelles fruit bat, *Pteropus seychellensis* (Bowler, 2006). *Pteropus seychellensis* is a common and widespread species and is present throughout the central granitic Seychelles. The larger islands all have roosts, and the smaller islands are host to what are described as temporary roosts (Racey, P.A. and Nicoll, M.E., 1984). Aride Island is host to such ‘temporary roosts’ and bats are not thought to breed here. However, Praslin, a large island six miles south of Aride, is host to permanent roosts and bats are often observed flying over the sea between the two islands. The bats have a preference for roosting in tall trees, such as *Casuarina* sp., and on Aride Island they are also observed roosting on coconut palms *Cocos nucifera* and *Ficus* sp., among others. The bats have two major roosts – one that is used during the south-east monsoon (so called because of the direction of the prevailing trade winds) May to October, and one during the north-west monsoon, November to April (Racey, P.A. and Nicoll, M.E., 1984). *P. seychellensis* prefers sweet, soft fruits (such as mango, Indian almond, various *Ficus* species) and nectar (e.g. butter nut *Pentadesma butyracea* and kapok *Ceiba pentandra*), which makes this species a potential seed disperser and pollinator (Racey, P.A. and Nicoll, M.E., 1984). The fruit bats of Aride Island remain largely unstudied – there have been sporadic roost counts since 1989, and, between 1993-2001, monthly maxima were recorded for the coastal *Causuarina* roost. In recent years the bats have not been monitored at all. Seychelles fruit bats are common and widespread but face a number of threats – consumption by humans, killed as a pest species when feeding in gardens on larger islands and electrocution on roadside wires (Bowler, 2006). Given the rate of development throughout the Seychelles (and of course the associated habitat destruction), Aride could become an important stronghold for the fruit bat, particularly since the habitat of Aride is transitional, and moving from a forest dominated by *Pisonia grandis* towards a more diverse forest with fruit bat-favoured species such as *Ficus* (Mills, S, pers. comm). Taking this into
account, this study sets out to establish data on the distribution and feeding habits of the *Pteropus seychellensis* population on Aride and to set up a simple but effective methodology for continued monitoring of this species.

**Methods**

Presently, there is not a single survey method considered suited to all fruit bat species in all situations (Mickleburgh, S.P., Hutson, A.M and Racey, P.A, 1992). Direct counts are possible at known roost sites, but surveying becomes more difficult where there are bats present in large areas at lower densities. The once large *Causuarina* roosts of Aride are no longer present, and so other survey methods must be undertaken (Aride Island Annual Report, 2006). Line transects (similar to those used extensively for birds) are a proposed method for studying bats in lower densities – given the small size of Aride (73ha) and the lack of large roosts, line transects would appear to be the best way to study the fruit bats of the island (Mickleburgh, S.P., Hutson, A.M and Racey, P.A, 1992).

500m transects were measured in four different areas of the island: south-facing beach, plateau, hill and eastern rocks. These are well-spaced in an attempt to gain knowledge of how fruit bats use the island, but are also restricted somewhat by accessibility – most follow already established paths (see fig. 1.1). Each of these transects was surveyed on foot once a week at 1730hrs – the best time to study as bats leave daytime roosts at dusk to feed, and walked at a standardised speed of 4km/hr (Mickleburgh, S.P., Hutson, A.M and Racey, P.A, 1992). This speed is recommended by Bibby, Burgess *et al* in Bird Census Techniques (1993) for denser habitats; almost all the transects include areas of thick vegetation. The location of all Seychelles fruit bats detected (using 10.5 x 42 binoculars) within a 10m belt on either side of the transect were recorded on a map of each transect, on which their behaviour was additionally recorded in broad categories – flying, feeding and roosting. The tree species that feeding or roosting bats were found on was also recorded. All survey work was carried out between 5th October and 13th November.
**Results**

Figure 2.1 shows the total number of bats observed on all transects, with the hill and plateau transects showing the greatest number of fruit bats, 185 and 83 respectively. The eastern rocks transect had far fewer bats (25) and the beach transect the fewest of all (11). Figure 2.2 shows the results of Mann-Whitney $U$-tests carried out on the data shown in figure 2.1. This is a non-parametric statistical technique that compares the medians of two samples of different sizes (Fowler and Cohen). Six Mann-Whitney $U$-test statistics were calculated along with the corresponding p value of each. The median number of bats observed was significantly different when comparing the eastern rocks and hill transects, the beach and the hill transects and the plateau and the beach transects.
Figure 2.1 Total number of Seychelles fruit bats observed (the sum of all observations from six surveys) on the four different transects.

<table>
<thead>
<tr>
<th></th>
<th>Eastern Rocks</th>
<th>Beach</th>
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<tr>
<td>Eastern Rocks</td>
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<td>Beach</td>
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<td>Hill</td>
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<td></td>
<td>$p = 0.0303$</td>
<td>$p = 0.0047$</td>
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<tr>
<td>Plateau</td>
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<td>$U = 22.0$</td>
<td>$U = 46.5$</td>
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<td></td>
<td>$p = 0.091$</td>
<td>$p = 0.0074$</td>
<td>$p = 0.2615$</td>
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Figure 2.2 Results of Mann-Whitney U-Test, showing $U$ and $p$ values for comparisons between each of the transects. Statistically significant $p$ values are shown in bold ($p<0.05$).

Figure 2.3 shows the change in bat numbers on each transect through time. The number of bats are sightings of individuals. Figure 2.4 summarises the observed behaviour of all the bats counted in this study. Feeding was by far the most commonly observed behaviour – 75% of the bats observed were seen to be feeding. The table (fig 2.5) shows what tree species bats were noted to be feeding on. All tree species in the table are considered to be ‘highly attractive’ to fruit bats and are found on Aride (Racey, P.A. and Nicoll, M.E., 1984). Every feeding bat located in this study (229 individuals) was found to be feeding on *Ficus* species.
Figure 2.3 Number of bats observed on each survey.

Figure 2.4 The observed behaviour of all fruit bats recorded during this study (a total of 304 individuals).
From this study, it would appear that *Pteropus seychellensis* displays a clustered, patchy distribution across Aride. The hill transect was by far the most populated area, followed by the plateau, and then much smaller numbers observed on the eastern rocks transect and the beach (Fig 2.1). The Mann-Whitney U-Tests found that three of these transects were statistically significantly different from each other – the hill and the beach, the hill and eastern rocks, and the plateau and the beach. This difference can possibly be attributed to the prominence of *Ficus* species on the hill as compared to the beach and, to a lesser extent, eastern rocks. Fursinger and Putallaz, 2008, carried out comprehensive vegetation monitoring on Aride, finding that *Ficus reflexa* and *Ficus nautarum* were, respectively, the 3rd and 4th most abundant plant species on the island. They also found that on the hill these species increased in relative abundance and density. The beach fringe has no *Ficus* species trees and is dominated instead by *Scaevola sericea* and *Pisonia grandis*, which explains the lack of feeding bats present in this area. The fruits of *Ficus* species, of which there are two on the island – *Ficus reflexa* and *Ficus nautarum*, are both considered to be ‘highly attractive’ to Seychelles fruit bats (Racey, P.A. and Nicoll, M.E., 1984). Given that all of the bats observed feeding during this study were found to be feeding on *Ficus* sp. (see fig 2.5) and that this was by far the most observed behaviour (75% of observed individuals were feeding), a positive correlation can be inferred between the distribution of feeding bats and density and abundance of adult *Ficus* trees.

The plateau transect actually takes in two differing plant communities – the ten metre belt to the left of the transect was the coastal forest of the plateau itself, consisting of tall Indian Almond (*Terminalia catappa*), *Pisonia grandis* and few *Ficus*. The ten metre belt to the right of the transect was more akin to the hillside community where there are far greater numbers of *Ficus* sp. As this transect was

<table>
<thead>
<tr>
<th>Tree species</th>
<th>Ficus sp.</th>
<th>Carica papaya</th>
<th>Ochorosia oppositifolia</th>
<th>Terminalia catappa</th>
<th>Artocarpus altilis</th>
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<tr>
<td>Total number of feeding bats observed</td>
<td>229</td>
<td>0</td>
<td>0</td>
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</table>

*Figure 2.5 The number of all observed feeding bats found on different tree species.*

**Discussion**

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thus a combination of two different plant communities, it is possibly not surprising that the bat numbers observed sat between the high numbers of the hillside transect and the lower numbers of the beach. The plateau transect also included the cultivated area of the island, where there is breadfruit *Artocarpus altilis*, papaya *Carica papaya* and the aptly named fruit bat tree *Ochorosia oppositifolia*; all of which Aride bats have been observed feeding on, but none were seen eating these fruits during this study.

It is notable that on the eastern rocks transect few bats were observed. The Aride vegetation survey by Fursinger and Putallaz (2008) notes that on the hillside *Ficus* sp. are common, and eastern rocks comes into this ‘hillside’ category. However, it is possible to distinguish this from the other hillside transect as there is a greater proportion of boulder cover represented at eastern rocks, and there is a larger community of *Pisonia grandis* and *Euphorbia pyrifolia*, with fewer *Ficus* sp. trees. This goes some way to explaining the lower feeding bat numbers.

Also noteworthy is that although bat numbers were found to be very low on the beach transect, historically the tall coastal whistling pine trees (*Casuarina equisetifolia*) have been large bat roosts, with up to 200 bats counted in October 1994 (Aride Island Annual Report, 2006). Even when casually observing these trees between 1730hrs and 1900hrs, few bats were found to be roosting.

An inference about the population of fruit bats on Aride requires a fair degree of speculation, given the lack of solid historical data. It is clear that the fruit bat population of Aride is highly variable (see fig 2.3). Bats are observed to fly over from Praslin prior to dusk, and their preference of roost location may well vary with prevailing weather conditions (as well as the decision to fly over from Praslin or not). Bat numbers will also be affected during November, as they do not breed on Aride; most Aride bats are presumed to breed on Praslin. There is a small amount of evidence here (fig 2.3) to support the fact that bat numbers began to fall off towards the end of the study, which finished on the 13th of November.

It would appear that the strongest factor affecting *P. seychellensis* distribution on Aride at dusk is the presence of *Ficus* species trees in which to feed (fig 2.5). As the most common food species for bats on the island, it is not surprising to find large congregations of these bats feeding together on a single tree.
To improve knowledge of Aride’s Seychelles fruit bat population, regular survey by line transect, as per this study, is essential. As an endemic species with a lack of solid data, it is imperative that it is monitored, particularly as the importance of Aride for this species may increase. Correlation with other data (weather, tree fruiting episodes, timing of the changes from South-East monsoon to North-West and vice-versa) will help to build the picture of how the bats use the island through the year. It would also be useful to carry out surveys of the bats at different times – this will help to build data on how the bats use the island on a temporal scale, and how many are actually resident on the island at any given time. Future reserve management should account for the importance of *Ficus* species for fruit bats, particularly given the continued threats of human consumption and habitat loss on other islands.

**References**


Mills, S. Personal communication with Aride Warden.


Appendix 14


Chloe Arnold, Sally Mills and Melvyn Yeandle.

Introduction

Aride Island is the most northerly of the granitic islands of Seychelles, located approximately 4° south of the equator it is 1.6km long and 0.6km wide. It has been a nature reserve since 1973 when Christopher Cadbury bought it on behalf of the Royal Society of Nature Conservation. Aride was designated a Special Nature Reserve (SNR) under Seychelles law in 1975. Originally a coconut plantation, the island’s vegetation has been restored to represent native coastal forest. It is currently managed by the Island Conservation Society (ICS), a Seychellois non-governmental organisation and is the most important seabird colony in the western Indian Ocean; only Aldabra has a greater number of breeding species (Bowler et al., 2002).

Aride has 10 species of breeding seabird. Audubon’s shearwaters, white-tailed tropicbirds and fairy terns breed all year round on the island, although the fairy terns lay most eggs from January to March (Skerrett et al., 2001). Wedge-tailed shearwaters, roseate terns, sooty terns, lesser noddys and brown noddys breed predominantly during the south-east monsoon which occurs from May to October, although a small number of lesser and brown noddys nest during the north-west monsoon which occurs from November to April (Skerrett et al., 2001). The red-tailed tropicbird breeds predominantly in the north-west monsoon. Bridled terns have an eight to nine month breeding cycle and so the time of year when breeding occurs is variable.

Amongst other reasons, Aride was established as a nature reserve to protect the seabird colonies. An annual seabird census was established in 1988 to monitor the number of breeding pairs of the five most wide-spread species; white-tailed tropicbirds, fairy terns, sooty terns, brown and lesser noddys. By monitoring the breeding numbers any changes could then be attributed to factors such as feeding conditions, poaching activity, habitat change due to the recolonisation of the island’s remaining vegetation and, in the long term, climate change.
Initially the census was conducted bi-annually in January or February and June or July. It was conducted twice a year to obtain information on those species which breed year round. The survey method used four fixed belt transects which were specifically located to represent all of the habitats present on the island (Bullock, 1989). The results of the surveys conducted from 1988 to 2000 were published in a scientific paper by Bowler et al. in 2002.

In 2003 the census was conducted using both the belt transect method and the circular plot method. The circular plot method involved establishing a 50m grid on the island. Every other point is surveyed one year (the grid) and the intermediate points are surveyed the next year (the inter-grid). The circular plot method was employed to provide a systematic sampling procedure which would give a more representative sample of the island as a whole compared to the belt transect (Sampson and Rocamora, 2007).

Both the belt transect and circular plot were run in parallel from 2003 to 2007 to show the correlation between the two methods and to ensure that the pre and post 2003 data would be comparable (Sampson and Rocamora, 2007). In the analysis presented in this report the data, from 2003 the data was obtained from the circular plot method and pre 2003 from the belt transect method. It was found that the belt transect method overestimated the number of breeding pairs of sooty terns by 50%, therefore all pre-2003 sooty tern data has been reduced by 50% accordingly.

From 2003 onwards, the census was only conducted in the south-east monsoon therefore all data (unless otherwise stated) was obtained from the south-east surveys.

For the fairy terns and the white-tailed tropicbirds, the analysis has been performed somewhat differently. The data from the south-east from 1988 to 2008 was analysed as mentioned above. Additionally, the transect data from 1998-2003 has been analysed to compare the results obtained in the two monsoons.

In this report, the number of breeding pairs of the five most widespread seabird species have been analysed. Statistical analysis, in the form of regression analysis has been applied to the data. This method uses mathematical techniques to fit a line through the data points in a graph. The line shows if there is a trend in the data and if there is, whether the trend is significant.

The aim of this report is to analyse the seabird data collected from 1988 to 2008 and show any trends in the data. This important information can then be used to influence the future management of Aride Island.
Results

Sooty Tern

Figure 1. Number of pairs of sooty terns nesting on Aride during the south-east monsoon, 1988-2008.

Although the number of pairs of breeding sooty terns on Aride is highly variable (figure 1), there has been a decline over the period 1988 - 2008. However, the decline is not significant ($F = 1.99$, $p = 0.176$). The most recent survey in 2008 showed a very low number of breeding birds, the lowest in the history of the survey. Bowler et al. (2002) also noted variable numbers of breeding birds between 1988 and 2000, although no overall trend was observed.

Brown Noddy

There has been a very slight decline in the number of pairs of brown noddys nesting on Aride between 1988 and 2008 (figure 2) although this is not statistically significant ($F = 0.01$, $p = 0.921$). Despite being variable between years the number of breeding pairs appears stable, no trend in numbers was found from 1988 to 2000 (Bowler et al., 2002). Low numbers of breeding pairs were present on the island in 2000 and 2008. The inclusion of these years in this analysis therefore may account for the slight decline in numbers and the breeding numbers appear stable overall.

This species has a minority which nest out of season mainly from December to February (Skerrett et al., 2001). Therefore although a slight decline has been seen, there are other members of this species breeding during the year.
Figure 2. Number of pairs of brown noddys nesting on Aride during the south-east monsoon, 1988-2008.

Lesser Noddy

Figure 3. Number of pairs of lesser noddys nesting on Aride during the south-east monsoon, 1988-2007.
The number of breeding pairs of lesser noddy increased on Aride between 1988 and 2007 (figure 3), although the increase is not statistically significant ($F = 3.76$, $p = 0.073$). Three years of data were removed from the analysis, 1991, 2000 and 2008. The number of breeding pairs in these years was exceptionally low (<50,200 pairs) and not representative of the norm therefore these years were excluded from the analysis. Conversely, Bowler et al. (2002) reported a decline in the number of breeding pairs between 1988 and 2000, although the decline was not significant.

**Fairy Tern**

![Fairy Tern Graph](image)

Figure 4. Number of pairs of fairy terns nesting on Aride during the south-east monsoon, 1988-2008.

The number of pairs of fairy terns nesting on Aride increased significantly between 1988 and 2008 ($F = 4.93$, $p < 0.05$), at a rate of 75 pairs per year (figure 4). No obvious trend in numbers of breeding pairs existed from 1988 to 2000 (Bowler et al. 2002).

A comparison of the breeding numbers in the south-east and north-west monsoons from 1988-2003 (figure 5), shows a greater number of breeding pairs during the north-west monsoon. Bowler et al. (2002) found a significantly greater number of birds nesting in the north-west monsoon than in southeast monsoon from 1988-2000. Figure 5 shows that the number of breeding pairs during the north-west monsoon decreased slightly between 1989 and 2003, while the number of pairs breeding during the south-east increased over the same period, although neither trend is significant (south-east; $F=1.89$, $p=0.199$ and north-west; $F=0.22$, $p=0.65$).
Figure 5. Comparison of the number of fairy terns nesting on Aride during the south-east and the north-west monsoons, 1989 - 2003.

White-tailed Tropicbird

Figure 6. Number of pairs of white-tailed tropicbirds nesting on Aride during the south-east monsoon, 1988-2008.
A very slight decline in the numbers of breeding pairs of white-tailed tropicbirds nesting on Aride during the south-east monsoon was observed between 1988 and 2008 (figure 6). However, the decline was not significant \( F = 0.01, p = 0.925 \) and the population although variable, appears to be stable.

Bowler et al. (2002) found that the numbers of pairs of white-tailed tropicbirds nesting in the south-east and north-west monsoons were not significantly different between 1988 and 2000. A comparison of the data from 1988-2003 in figure 7 showed a slight decline in the numbers of nesting birds on Aride during the south-east monsoon although this decline was not significant \( F=0.09, p=0.775 \). However, during the north-west monsoon the number of breeding pairs declined significantly \( F=10.46, p=0.009 \) at a rate of 43 pairs per year. From 1988 to 2000, Bowler et al. (2002) found a significant decline in the numbers of breeding pairs in both monsoons.

![Figure 7. Comparison of the number of white-tailed tropicbirds nesting on Aride during the south-east and the north-west monsoons, 1989 - 2003.](image)

**Discussion**

For the five seabird species analysed in this report, the number of nesting pairs observed on Aride between 1988 and 2008 is variable for each species, as would be expected. Despite variation the overall trends in the number of breeding pairs show that the brown noddy appears stable, while lesser noddys and fairy terns have increased with the latter significant at a rate of 75 pairs per year. Sooty terns and white-tailed tropicbirds have experienced declines in the number of breeding pairs, with the latter
illustrating a significant decline during the north-west monsoon from 1988 to 2003.

As a habitat Aride Island has been in a transitional state for many years, created by human intervention. It was only 41 years ago that Aride was managed to promote the sooty tern population, creating terraces and clear areas to encourage them to breed for egg collection. Then as recent as 1973 when the island became a nature reserve and the coconut palms were removed. Such activities are examples of acts which have had a direct impact on the breeding populations over the years and that are current on Aride today.

The trends in breeding bird populations highlighted by this analysis would suggest that although Aride is still made up of habitats in transition there are indications that the developing habitats are starting to effect populations of certain species and to some extent favour one over the other. The question is will this trend continue and if so will it have a major effect on the species concerned?

As with any transitional habitat, by the very nature of their makeup they will change over time, succession will take place and as a result an effect on the resident species within the habitat would be expected. Both from casual observations and habitat monitoring it has been seen that Aride has gone through a series of successional stages over the last 20 years and this has especially been marked by the reduction of bare rock and open areas. In 1990 areas of different habitats were assessed through aerial photographs, revealing 5.2ha of plateau area, 49ha of hill woodland, 2.1ha of open grassland or ‘glade’, and 17.6ha of ‘open rock’. (Bowler et al., 2002). However in 1998 and 2005, Martin and Hunter respectively both confirmed that, apart from a few small bare rocky areas, the whole island is covered by a mature woodland dominated by Pisonia trees ca. 15 - 20m tall with dense canopy cover, while the understorey is dominated by a crescent number of small trees ca 2-6m high (eg Ficus reflexa, F. Nautarum, Euphorbia pyrifolia) and ferns Nephrolepsis biserrata. Habitat changes, especially in relation to vegetation structure, seem to be important in explaining distribution and abundance of seabirds on Aride Island (Catry et al., 2007).

In the very crude habitat assessments that were undertaken as part of the 2008 seabird census it was found that there were some changes to the habitat makeup as would be expected. This work revealed that the total woodland area had increased to 53ha, however with a closed canopy it remained similar at 48ha, with the additional 5ha being made up of woodland with a more open canopy, which in the past may well have been classified as glade area. However in this less dense 5ha the understorey make up was significant; 2.3ha was dense fern (Nephrolepsis biserrata), and only the remaining 2.7ha was classed as bare ground with sparse vegetative cover. This work revealed that the area of glade now on Aride is much reduced with the only permanent one on the hill located near Marks house, Icterine Glade, totalling approximately 0.2ha. It was also found that
the area of bare rock had been encroached and was calculated to be in the region of 15ha compared to the 17.6ha in 1990.

In 2008 at the time of writing this paper the dominant woodland species on Aride is *Pisonia grandis*, a tree species that has a very effective dispersal mechanism through its sticky seeds, enabling it to be very opportunistic in establishing itself across the island. However it appears that the dominance of this species on Aride is having a twofold effect:

1. By closing the canopy and limiting / reducing open areas.

2. Pisonnia’s opportunistic method of dispersal and reproduction not only allows it to successfully dominate over other vegetation, but it can have a devastating effect on certain bird species, by ‘sticking’ up their feathers, making them unable to fly, frequently causing a large number of fatalities.

The first factor is primarily illustrated through the analysis of the number of breeding pairs for the two main breeders on Aride; the sooty tern and the lesser noddy. The nesting requirements of the two species are very different, the former predominately requiring open areas, with large numbers of sooty terns nesting in open areas of glade and granite rock, (Bowler et al., 2002), and the latter a tree canopy. As a result the closing of the canopy has reduced the potential suitable breeding areas for sooty terns on Aride. Sooty terns (*Sterna fuscata*), are present at significantly lower densities compared to other islands of the archipelago with an open habitat and Feare et al. (1997) predicted that Aride’s population size might be constrained by canopy and understorey density in the future. This would begin to explain the reason for the decline illustrated in the breeding population over the last 20 years from 172,000 pairs in 1988 to 108,000 pairs in 2007. The numbers of sooty terns might have been expected to decline as native woodland regenerated on the hill since this ground nesting species typically uses flat open areas in which to breed (Bowler et al., 2002). It was found that birds regularly move from island to island and ringed birds from Aride were found to be nesting on Bird Island (Chris Feare, pers comm.) and it may well be that once the amount of available suitable habitat on Aride becomes much reduced that the sooty tern population may start to relocate to another island with more open habitat. Marked changes in colony size could thus reflect movements of birds to and from other breeding islands and future conservation management may need to focus on the Seychelles population as a single unit (Bowler et al., 2002). However it may well be that if the population does remain on Aride and continues to decrease in size that it will become more vulnerable to other factors, like *Pisonia grandis* and poaching as mentioned below.

However by contrast, the increase in the number of breeding pairs of lesser noddy from 140,000 in 1988 to 180,000 in 2007 reflects that they have benefited from a larger area of tree canopy being available. The breeding birds have opportunistically taken advantage of this change in habitat, resulting in an increase in the population bordering on significant.
It would seem that although the increase in canopy has been achieved predominately by *Pisonia grandis*, it is felt that it is not *Pisonia grandis* as a species that is the key factor in the increase in the number of breeding pairs of lesser noddies, rather the closing of the canopy. This is supported by many lesser noddys choosing other tree species to house their nests, including *Ficus* species and Takamaka, (*Calophyllum inophyllum*). However it must be acknowledged that *Pisonia grandis* does provide a building material that seems to be favoured by the nesting birds, the leaves form the foundations for many thousands of nests across the island.

To a similar degree the trend in the number of breeding pairs of fairy tern, which has increased significantly at a rate of 75 pairs per year over the last 20 years, also suggests that the increase in more mature trees across Aride has presented more opportunities for nesting through providing both structure and horizontal limbs within the makeup of the vegetation. However it was also suggested by Catry et al. in 2007 that the significant habitat changes that have been experienced on Aride, i.e. the large increase in canopy and understorey cover that occurred over the whole island, restricted the available white-tailed tropicbird breeding areas and that this was the cause of a major decrease in the breeding population.

The second factor is one that can affect all bird species, but particularly those which are ground nesters. The seed dispersal technique of *Pisonia grandis*; the sticky gum which the seeds exude, to stick to a host to transport them for dispersal, can be deadly to all bird species. The seeds are able to cling to birds’ feathers which once affected in 99% of cases will result in death. *Pisonia grandis* then uses the nutrients provided by these dead individuals to germinate its seeds and grow them on to saplings.

In addition to the first factor, the decline of the sooty tern population may well have been contributed to by young and adults birds being lost to the sticky seeds of *Pisonia grandis*. Moderate numbers of juveniles and a small number of adults were killed at the end of the 2007 breeding season by a *Pisonia* fruiting event (Sampson and Sampson, 2007). The ground nesting habits of the bird, particularly those which settle under partial canopy cover, means they instantly become vulnerable to a flowering event of *Pisonia grandis* and it is frequently the case that many casualties and carcasses will be seen throughout the breeding season.

From the analysis it can be seen that during the north-west monsoon from 1988 to 2003 the white-tailed tropic bird experienced a significant decline. Bowler et al. (2002) showed that the species had suffered an apparent decline of 60% between 1988 and 1998 on Aride, but the main causes for this decrease were never identified (Catry et al., 2007). However at the same time that Bowler et al. (2002) recorded this 60% decline on Aride, according to Phillips (1985) and Burger and Lawrence (2000) the neighbouring population on Cousin was increasing. As a result local factors were attributed to explaining the white-tailed tropicbird population decrease on Aride (Ramos et al., 2005). Catry went on to conclude that the local factors
that might account for the high mortality of adult tropic birds were most possibly loss of and quality of breeding habitats as mentioned above, nest site competition particularly with species such as wedgetailed shearwaters and periodic and intense fruiting of *Pisonia* trees (Catry et al., 2007). From observations in 2008, it seems that the white-tailed tropicbird as a ground nesting species severely suffered from the effects of *Pisonia grandis*. During a flowering event many birds are seen on the plateau and the beach covered in *Pisonia* seeds, becoming entangled by the seeds as they come across the island in an attempt to get to the sea. By this time 90% are near to death, the remaining 10% if they make it to the water are later found washed up on the tide line (Mills pers comm.). Catry et al. (2007) also found that tropicbirds found entangled in the *Pisonia* infructescences are still able to fly at the moment of capture during sampling, but would then die later. It is later concluded by Catry et al. (2007) that without these local mortality factors the growth of the population of white-tailed tropicbirds on Aride would be positive.

Although it is recognised that *Pisonia grandis* is a transitional tree species, which no doubt will find its natural level of dominance and niche on Aride as a species that can cope with extremes; thin soils and low nutrients. In the future through succession it will probably reach a point when it may well be out competed by other species such as Takamaka and *Ficus*, producing a more balanced system. However it cannot be ignored that the trend illustrated by the analysis of the northwest monsoon white tailed tropic bird breeding population is one in significant decline. The question may well be how long can this species survive this trend, will it be long enough for *Pisonia grandis* to find its natural level? Catry concluded that by using the population matrix that they had developed for analysis, the population of white-tailed tropic birds on Aride at the current rate of decline of 3.8% annually, will be extinct in approximately 120 years. Catry et al. (2007) estimated a timeframe for extinction based on a gradual population decline. An alternative possibility is that as the population declines, it may reach a point where the decline becomes exponential. The concern is that if bird species diversity is to be maintained the timeframe of the influence of *Pisonia* in relation to species survival needs to be considered.

For other seabird species the effects of the sticky seeds of *Pisonia grandis* as a single factor may not be seen to affect them dramatically, particularly when the percentage of deaths may not be considered as significant in context of the populations levels that Aride supports. However its effect in conjunction with other factors may well be an issue as Catry et al. (2007) raised as the case for the white-tailed tropic bird. The ability of *Pisonia grandis* to time its seed production to coincide with the seabird breeding season, together with other pressures such as poaching and habitat loss, may result in a total significant effect. This too is particularly pertinent to the sooty tern.

Poaching and its effect on the sooty tern population is extremely hard to evaluate and will be variable from year to year, but like *Pisonia grandis* and habitat loss, it must be acknowledged that it is potentially a significant
contributor to the decline in the breeding population that is illustrated in the analysis. Although the decline is not yet seen as significant the figures suggest that this downward trend may continue.

As an example of multiple factors effecting populations, during the breeding season of 2008 Aride saw poaching together with a La Nina year, reduce 100,000 breeding pairs of sooty terns in 2007 down to 40,000 pairs. La Nina caused poor food availability throughout the season and as a result the birds were not in a suitable position to relay and counteract the effects of the first eggs being lost to poaching, that they may do in more typical year. The impacts of such events are still poorly known (Weimerskirch, 2002).

Once again whilst sooty terns can typically recover from poaching events by relaying two or three times, when such events occurs as they did in 2008 in parallel, how stable is the population to deal with such pressures if they continue, when also faced with loss of habitat and deaths due to the dispersal of *Pisonia grandis*.

**Conclusion**

The data collected during the annual seabird census over the last 20 years is now of a sufficient quantity to provide meaningful insight into the dynamics of the breeding populations of several seabird species on Aride. The birds act as environmental indicators, illustrating the continual change and development of the islands’ habitats. The findings have highlighted the fundamental relationship between seabirds and the vegetation makeup and structure. As a result of the closing of the canopy on Aride over the last 20 years, lesser noddys and fairy terns have benefited, while sooty terns and white-tailed tropicbirds have suffered deleterious effects. Secondary factors such as *Pisonia* fruiting and poaching can influence the numbers of breeding seabirds and have the potential to push vulnerable populations over the edge. In the case of *Pisonia*, does the time frame in which the species will reach natural levels need consideration in the Island’s future management? Whilst solutions to some of these factors will always be difficult, particularly for example in the stopping of poaching, the findings of this report enable informed decisions about future habitat management and direction to be made, based on past experience.

In order to move Aride forward towards future habitat management decisions there needs to be a clear vision as to the desired habitat makeup and species it will support. There are a number of options which could be taken to determine its direction.

- **Non intervention** - To allow the transitional habitat process to follow its own course, resulting in the current trends of species populations to continue.
- **Intervention** - To be habitat led and to steer the island’s habitats into a more natural diversity without the dominance and unnatural levels of
opportunistic species. This approach would encourage sustainable levels of breeding seabirds, and dramatically reduce the mortality as a result of species such as *Pisonia*.

- **Partial intervention** - To be species led and to undertake limited habitat management in an attempt to try and sustain current seabird breeding populations and halt the decline currently exhibited by certain species.

For the future of Aride to be lead by any of these options and to compensate for the lack of continuity that the management of the island currently experiences, a full encompassing management plan is needed, which is driven by a vision for the future and specific conservation objectives.

**References**


Catry, T., Ramos, J.A., Monticelli, D., Bowler, J., Jupiter, T. and Le Corre, M., in press. The role of adult survival in explaining the decline of white-tailed tropicbirds on Aride Island, Western Indian Ocean.


