A census of the population of the white-tailed tropicbird *Phaethon lepturus* nesting on Aride Island, Seychelles

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Introduction

Aride Island (4°13' S, 55°44' E) is the northernmost of the granitic islands in Seychelles, Indian Ocean, and has been managed by the Royal Society for Nature Conservation as a nature reserve since 1973. Its 72 ha of rocky hill woodland, reaching 135m at the summit, and flat, wooded coastal plain are home annually to over 1 million breeding seabirds of 10 different species (Betts, 1996, Betts, 1997, Bowler & Hunter, 1998).

Here, the white-tailed tropicbird *Phaethon lepturus* holds one of its largest breeding populations worldwide (Betts, 1997). It typically nests on the ground, in crevices, the shade of boulders and rock overhangs, and sometimes in the buttresses of high trees (Penny, 1974). The subspecies *P. l. lepturus* occurring in the Indian Ocean generally breeds aseasonally (Harrison, 1983) and, as shown by studies both on Aride (Sheridan, 1997) and its neighbouring island Cousin (Phillips, 1985), also asynchronously in at least the northern granitic Seychelles.

Knowledge of breeding numbers over time is essential for population trends to be detected, and for the implementation of long-term conservation. However, the seabird censusing methods currently used on Aride, based upon evenly-spread, not independent sampling units (four 12.5m-wide transects, of various lengths, set up at arbitrary intervals from east to west across the island), are both statistically flawed and do not take into account this species' non-random nesting distribution (Phillips, 1985). This results in the large standard error of recent population estimates (Betts, 1998), and the method urgently demands substitution by a more scientifically sound censusing technique, geared towards the special breeding characteristics of white-tailed tropicbirds.

The purpose of this study was to devise a more reliable, yet efficient method to monitor the numbers of breeding white-tailed tropicbirds on Aride. This will be achieved through a preliminary survey to map out areas of differing nesting densities, and by working out the optimal sample size for each of the identified areas of nesting density to produce future estimates.

Aims

- To locate and count as many nests as possible in order to identify areas of differing nesting densities.
- To compare the results with findings from previous years to ascertain the reliability of previous estimates that used other methods
- To identify clusters of nest sites to allow future establishment of sampling plots within areas of differing nest density for more precise population estimates

Methods

Field work was started on 8 December 1999 and finished on 24 February 2000.This included 4 weeks of locating and counting all apparently occupied nest sites (AONs, meaning a chick, or an adult in a nest cavity, with or without an egg or chick) (Burger & Lawrence, 1999) and a consecutive seven weeks of taking sample counts within the identified nesting aggregations. Considering the asynchronous character of the species' breeding cycle (Phillips,1985), it was impossible for the surveying and sampling to cover identical nest sites. However, as this species breeds all year round (Phillips, 1985), the seasonal variation in numbers of breeding pairs was regarded as negligible (Bowler, pers. Comm.) and we would expect to find similar numbers of active nests at any cluster at any one point in time (Fig.1).

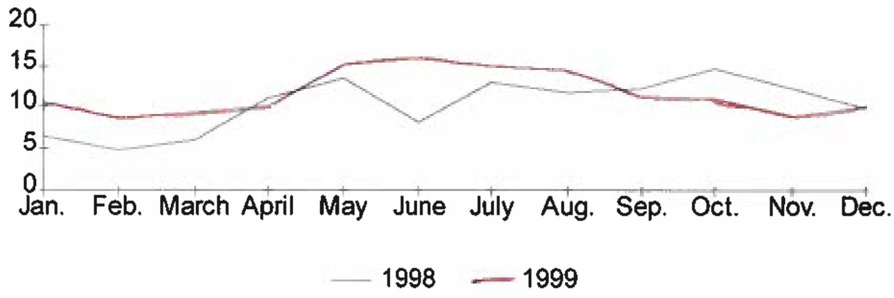
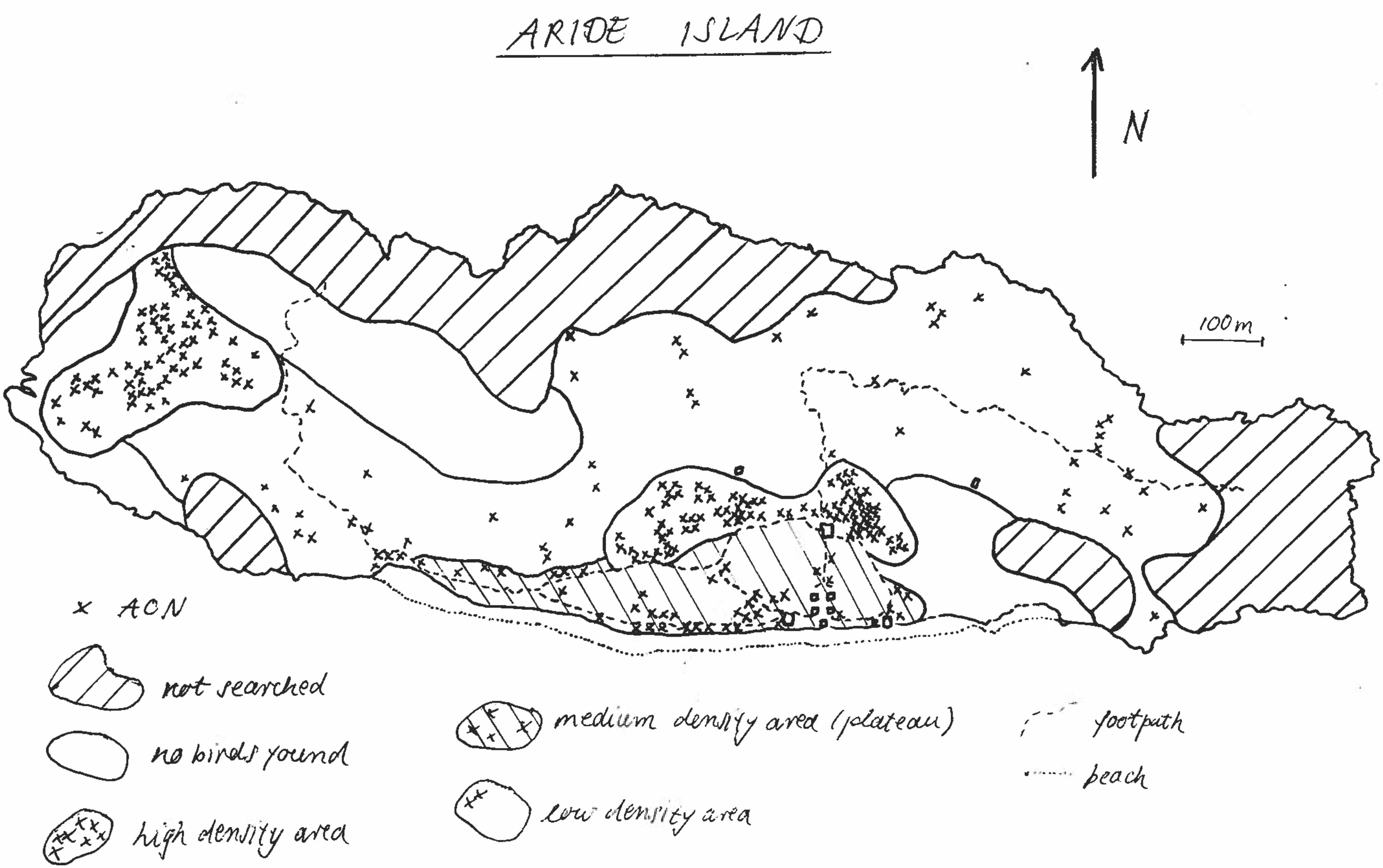


Fig. 1: Breeding periodicity of white-tailed tropicbirds on Aride in 1998 and 1999.

Data for breeding periodicity was derived from the island's long-term study site for this species. It is based on 50 AONs each year that were checked weekly for occupancy and productivity. The examples from the last two years show both monthly and weekly (monthly figures are based on averages from weekly counts) fluctuations in breeding numbers (mean 1998 = 10.325 pairs, mean 1999 = 11.7125 pairs). Unfortunately, it was impossible at the time of data analysis to backdate time of laying for individual nests, which means there is no measure of the degree of overlap in breeding cycles between potential sub-populations. Without an idea of the rate of turnover of breeding pairs at individual nest sites per year, it is impossible to infer judgements about the stability of breeding numbers throughout the year.

<u>Mapping</u>

After surveying the plateau, the hill woodland was searched systematically for occupied nests, from East to West. Areas that were either too steep or too densely vegetated to allow access to the ground, or that did not contain any rocks to provide shade for the animals were ignored, because they were considered unsuitable as breeding habitat (map 1). Locations of AONs were judged by eye and marked on a map as precisely as possible.


ARIDE ISLAND
N
100m
× AON
not searched
no birds found
high density area
medium density area (plateau)
low density area
footpath
beach

Even though it may be difficult to relocate individual AONs in future studies, the general areas of clusters were identified confidently.

Sampling

Sampling methods were kept as compatible as possible with others currently used for this species in Seychelles, to allow comparisons and overall conclusions for this area to be drawn. In accordance with Burger & Lawrence's 1999 study on Cousin, sampling plots were chosen to be circular both for simplicity of set-up (string held by a person or tied round a tree in the centre) and to minimise edge effects causing unnecessary disturbance to birds. Using the formula $\pi r^2 = 0.03125$ ha, to achieve the plot size of 0.03125 ha, which corresponded to both Aride's seabird censusing methods and the Cousin study, the radius of the circular plots and thus the string length had to be r = 9.97m (r = 10.00m on Cousin).

Plot locations were chosen randomly from 50m x 50m grid sections for each of the four nesting density categories for the area (division based on visual impression into high, medium and low density and no AONs found at all – see map 1). Numbers of plots necessary for each category were worked out by determining the point at which mean densities and their standard deviations remained stable despite an increase in sample size (stable mean density being a measure of accuracy, standard deviation of precision). This was done every day to decide if further sampling was needed to produce a reliable estimate of that particular density category.

Results

A total of 242 AONs was found, with an average density of 3.36 AONs/ha. The non-random distribution of nests (map 1) is epitomised by two high density patches adjacent to large areas of low density or "no nests at all-" patches.

The heterogeneous character of the clusters allowed the establishment of the four major density categories, each of which contribute different proportions to the total breeding population (table I).

area type	area size (ha)	% area of total	no. nests foun	no. nests/ha
plateau	5.24	7.28	40	7.63
hill (high density	7.15	9.93	152	21.26
hill (low density)	29.48	40.94	50	1.7
no nests found	12.08	16.78	0	0
not searched	18.05	25.07	0	0

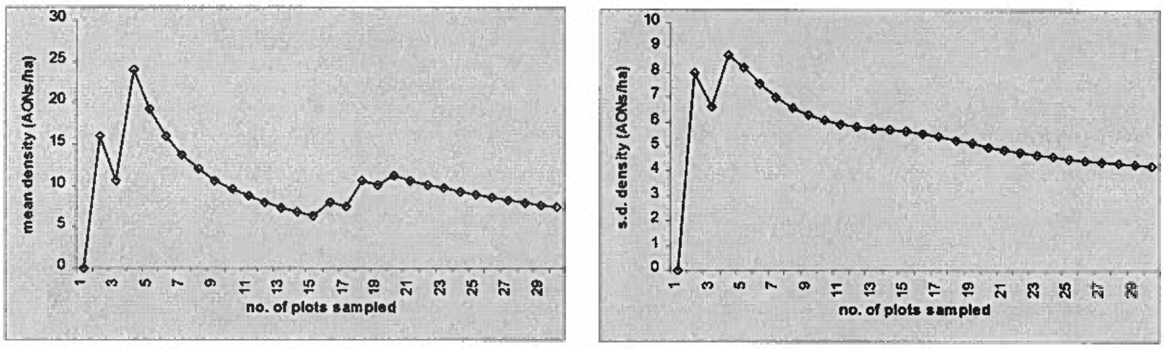
Table I: AONs (here: "nests") found in each density category (here: "area type").

Despite occupying a relatively small percentage of the total area, the high density patches on the hill make up over half of the total number of AONs. Similarly, the plateau contributes almost as many, because more densely packed nests as the rest of the hillside, even though its size is much smaller.

Sampling

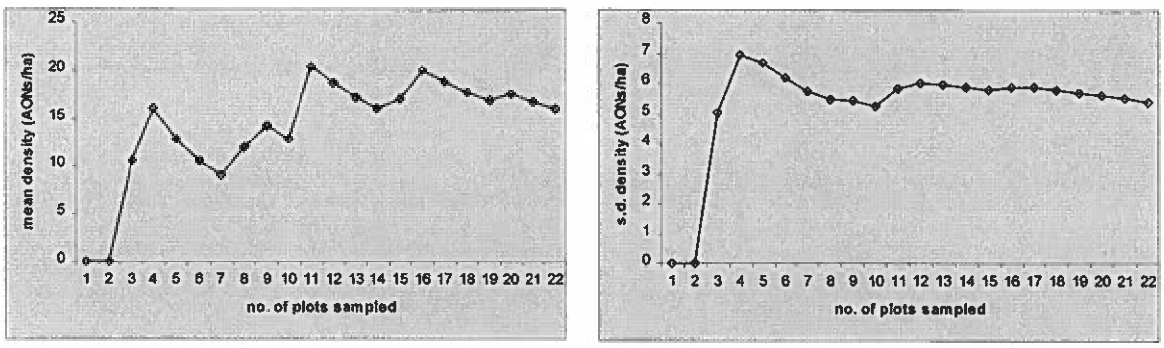
In the low density area, standard deviations level off only gradually, but consistently after a peak at five plots, whereas mean densities only level off after 20 (fig. 2).

Figure 2: Change of mean density of AONs (left graph) and standard deviation (right graph) with increasing sampling effort in the low density area.



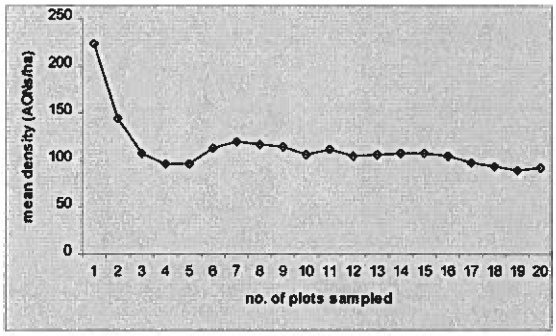
On the plateau, both mean densities and their standard deviations find a more or less constant level later than those of samples taken in the low density area. Standard deviations become very similar, even almost completely stop sloping, after 12 plots, while the mean density peaks only start smoothing out at the end of the total sampling (fig. 3).

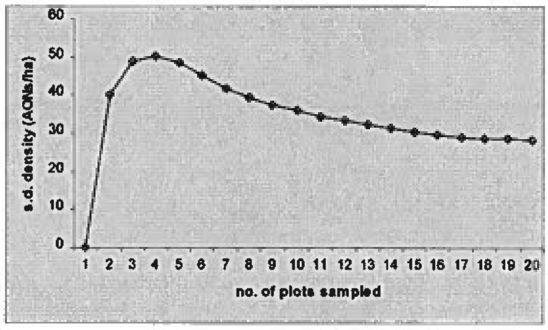
Figure 3: Change of mean density of AONs (left graph) and standard deviation (right graph) with increasing sampling effort on the plateau (medium density).



Even though both mean density and standard deviation graphs start levelling off after a reasonably small area sampled (after about five in both cases), again, they continue to decrease right until the end in the high density area(fig. 4).

Figure 4: Change of mean density of AONs (left graph) and standard deviation (right graph) with increasing sampling effort in the high density area.





Discussion

Because there is no at which both mean densities and, more importantly, standard deviations can objectively be said to have levelled of completely, the identification of the point of "optimum sample size" still is, to an extent, arbitrary. When bearing in mind the aims of reliability of the data produced in future by these methods and their time-efficiency in the field, it still seems justified to make some subjective, yet informed decisions based on a trade-off between these two aspects (goals?).

I recommend the following numbers of circular 0.3125ha plots to be done in order to achieve statistically sound population estimates at minimum effort, even though an increase (or reduction) of 5 plots per category, if preferred, should not add (or take away) more than two days' extra effort.

Hill (low density): 20. Standard deviations have securely started evening out, and more effort does not produce proportionately enough decrease in variability.

Hill (high density): 15. The same effect is reached in this area quicker than in the low density area (probably because variability from plot to plot was not as high).

Plateau (medium density): 15. Even though this sample size covers proportionately a much greater area of the total respective area than the other two, individual plots were very variable and therefore require such a relatively high number of plots.

The more careful sampling produces, as expected, higher figures for each category than the mapping and the traditional methods (table II).

Table II: Comparison of population estimates and their precision produced by the three different methods mapping, sampling and traditional transects (based on January data).

Area type	No. AONs/ha (sampling)	No. AONs in total (sampling)	No. AONs in total (mapping)	No. AONs in total (seabird transects)
Plateau	17.6 ± 5.6	92.22 ± 29.39	40	N.A.
Hill (high density)	106.7 ± 30.39	762. 67 ± 217.34	152	N.A.
Hill (low density	11.2 ± 5.02	330.18 ± 148.11	50	N.A.
Total area		1185.07 ± 394.84	242	433 ± 258

The new methods produce not only higher, but also more precise estimates, which was a major aim of the study. The overall standard deviation was reduced to only 33% of the mean, while it was 60% in the January transects. The new methodology therefore can be said to have almost doubled precision of estimates.

It should be noted that the generally higher density of the plateau in comparison to most of the hillside might be due to heavy clustering of nests along the plateau paths. These, apart from largely being close to the sea, seem to be good access routes for both adults and fledglings. Given that the plateau forest still is growing back to a more natural state since its conversion from a coconut plantation, it will only be a few years until a more mature forest with larger canopy gaps will have formed to provide habitat for an even larger number of tropicbirds. In this case, and to be sure of the reliability of the sampling methods in general, future population estimates should always be based on samples that are checked for the slope of standard deviations and mean density, and that the number of sample plots should be increased if necessary.

The question of what to extrapolate from the point estimate for the annual breeding population remains. Both Sheridan on Aride (1997) and Stonehouse on Ascension (1962) were able to observe some extent of breeding synchronicity in the species at least until breeding turned out of phase through failures by individual pairs. Thus, despite the knowledge that breeding cycles are about three months long and intervals between these average 264 days on Aride (Sheridan, 1997), we cannot be sure that there will be equal numbers of birds at all different stages of their breeding cycle all the time. Not knowing how many pairs attempt to breed at individual sites per year, it will not be possible for me to give a definite answer to the question what proportion of the total breeding population my point estimate represents. To give a safe minimum estimate of breeding numbers, i.e. based on breeding individuals showing no overlap at all, the figure established by sampling should therefore be only doubled, rather than multiplied by four, which is how many cycles could theoretically be fitted into one year.

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