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Nest sites and breeding estimates of the Black Noddy *Anous minutus* on Lady Elliot Island

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The Black Noddy *Anous minutus* breeds on vegetated islands off the coast of Queensland, Australia, including Lady Elliot Island, the southern-most island in the Great Barrier Reef. An estimate of breeding pairs on Lady Elliot Island shows an increase on earlier estimates and approaches 30 000 pairs. Nests were found in ten species of tree/shrub. The highest density of nests (nests per tree) was in *Pisonia grandis* (45.2), followed by *Ficus opposita* and then *Heliotropium foertherianum* with the lowest in *Cocos nucifera* (5.9). More nests occurred in protected trees and shrubs than exposed. There was no relationship between the heights of plants and the height of nests. Nests were closest together in *H. foertherianum* but distances between nests varied with the habit of the tree/shrub.

INTRODUCTION

Although the Black Noddy *Anous minutus* is distributed widely across wooded tropical or subtropical islands, most of its Australian breeding records have come from islands off the coast of Queensland (Higgins and Davies 1996) including Lady Elliot Island (24º07' S; 152º43' E), the southern-most island in the Great Barrier Reef. Lady Elliot and islands of the nearby Bunker Group are coral cays with distinct natural vegetation. Dominant species of the outer forest are *Heliotropium foertherianum* (previously *Argusia argentea*) and *Casuarina equisetifolia* while the inner forest is dominated by *Pisonia grandis* (Wood 1984).

Walker (1986, 1989) stated that prior to 1985 few Black Noddies visited Lady Elliot Island and that the first Black Noddy colony on Lady Elliot Island consisted of 30 nests (1985–86). This number increased to 427 (1986–7), 455 (January 1988) and 570 (January 1989); most nests were in *C. equisetifolia* trees that covered almost half of the island (Walker 1989). Estimates for Heron Island (less than 100 km to the north-west and within the Capricorn Group of islands) show similar, though much larger, increases: around 8 500 breeding pairs (1975) (Kikkawa 1976), 29 000 (1982–3), 37 000 (1983–4) (Hulsman's 1983 and 1984 estimates adjusted by Barnes and Hill (1989)), 40 000 (1985) to around 70 000 (1989) (Hill *et al.* 1997), with a dip to about 63 000 (1992) (Ogden 1993b) and peaking to over 70 000 (1996–97) but dropping in the two subsequent years (1998–99: around 23 000; 1999–2000: around 30 000) (Dyer *et al.* 2005). No recent estimates of the number of breeding birds have been made for Lady Elliot Island.

On Heron Island, in one 5-metre tall *Ficus opposita* tree with 12 nests, the mean distance to the closest nest was 0.5 metres but as close as 12.7 centimetres and as far as 14 metres (Braithwaite 1973). In 1985, nests on Heron Island were in *P. grandis* (75%) as well as *F. opposita, Celtis paniculata, Cordia* sp., *H. foertherianum, Pandanus tectorius, C. equisetifolia* and other plants (Barnes and Hill 1989). The number of nests in *P. grandis, F. opposita* and *C. paniculata* generally increased with the height of the tree (Hulsman *et al.* 1984). The average number of nests per tree was from 1.5 ± 0.5 in *C. equisetifolia* to 25.9 ± 1.8 in large *P. grandis* trees (Barnes and Hill 1989).

On Masthead Island (~20 km SW of Heron Island), taller trees contained more nests than smaller trees while the highest nesting densities were found in *F. opposita* and *C. paniculata* (Hulsman *et al.* 1984); most nests (49.4%) were in *P. grandis* forest 6–8 metres tall (Dale *et al.* 1984, Hulsman *et al.* 1984).

Lady Elliot Island was cleared of almost all its vegetation from 1863–1873 to allow guano mining and then kept bare by the lighthouse keepers' goats until 1969. An active tree planting program of a variety of species, following the removal of goats, began in 1969 (Heatwole 1984). Dominant tree/shrub species are *C. equisetifolia, H. foertherianum, C nucifera, P. tectorius, P. grandis, Hibiscus tiliaceus* and *F. opposita*; the occurrence of *P. grandis* is lower than on Heron and Masthead islands that did not suffer from the effects of guano mining (Wood 1984). Despite the inclusion of weed control in the plan of management (V. Mullins, pers. comm.), from observations made during repeated trips over the previous five years, there is no apparent control of weeds that include *Lantana camara* as well as numerous herbs (see also Batianoff 1998).

This study aimed to determine the following for the Black Noddy on Lady Elliot Island:

- an estimate of the number of breeding pairs
- nest densities (nests/plant species) in sheltered and exposed trees/shrubs
- relationships between tree heights, nest heights and nest densities
- internest distances

TABLE 1

Black Noddy nests in immature (I) and mature (M) trees/shrubs, south-eastern Lady Elliot Island.

Tree/shrub	Total nests [nests/tree] (% nests occupied)	Number of nests per		Nest heights in	
		exposed tree	protected tree	exposed trees (m) mean ± SD	protected trees (m) mean ± SD
Casuarina equisetifolia (*n*=101)	891	95 nests; 73 trees = 1.3	796 nests; 28 trees = 28.4	Range: 1.5-16	Range: 1.1-16
All mature	[8.8]	27.4% trees had nests	89.3% trees had nests	Low = 9.2 ± 3.8 (*n*=15)	Low = 4.5 ± 3.7 (*n*=24)
	(95)			High = 9.7 ± 3.5 (*n*=22)	High = 8.5 ± 3.7 (*n*=25)
Cocos nucifera (*n*=94)	563	No exposed trees	563 nests; 94 trees = 5.9: (none <5m had nests)	No exposed trees	Range: 3-11
I=40.4%; 47.4% had nests	[5.9]		68.1% of trees had nests		Low = 5. 6 ± 2 (*n*=57)
M=59.6%; 85.7% had nests	(97)				High = 6.1 ± 2 (*n*=61)
Heliotropium foertherianum (*n*=54)	907	4 nests; 12 shrubs = 0.3	903 nests; 42 shrubs = 21.5	Range: 1.5-1.7	Range: 0.5-3.7
All mature	[16.8]	33% shrubs had nests	73.8% of shrubs had nests	High = 1.6 ± 0.1 (*n*=4)	Low = 1 ± 0.5 (*n*=31)
	(89)				High = 2.4 ± 0.8 *n*=31)
Pandanus tectorius (*n*=44)	319	123 nests; 24 trees = 5.1	196 nests; 9 trees = 21.8	Range: 1.5-7.5	Range: 1-5.5
I=25%; none had nests	[7.3]	87.5% trees had nests	100% trees had nests	Low = 3 ± 1.1 (*n*=21)	Low = 1.8 ± 0.6 (*n*=9)
M=75%; 97% had nests	(95)			High = 4.3 ± 1.4 (*n*=21)	High = 4.8 ± 0.7 (*n*=9)
Pisonia grandis (*n*=15)	678	No exposed trees	678 nests; 15 trees = 45.2	No exposed trees	Range: 0.5-13
All mature	[45.2]		93.3% trees had nests		Low = 3.7 ± 2.9 (*n*=13)
	(95)				High = 9.6 ± 2.9 (*n*=14)
Ficus opposita (*n*=7)	94	No exposed trees	94 nests; 7 trees = 19.4	No exposed trees	Range: 1-6
All mature	[19.4]		100% had nests		Low = 1.9 ± 0.7 (*n*=7)
	(100)				High = 2.9 ± 1.4 (*n*=7)

METHOD

During 10–15 January, 2012, all Black Noddy nests in all individuals of each species of tree in the south-eastern quadrant of Lady Elliot Island were counted and scored whether occupied or unoccupied. The south-eastern quadrant was chosen because it contained the greatest diversity of plants (including *C. nucifera*) and because most of the north-eastern and much of the north-western quadrants comprised low bushes/herbs not utilised at all by the Black Noddy. Dyer *et al.* (2005) suggest that estimating density per unit area is unacceptable in patchy distributions as occurs on Lady Elliot Island. As well, it is possible that the higher occurrence of people in the south-eastern quadrant may have had a deleterious effect on the breeding behaviour of the Black Noddy (see also Dyer *et al.* 2005) and it was considered better to under-project rather than over-project the number of nests for the whole island. If an unoccupied nest had a clear form and deposits of guano or a juvenile bird nearby, it was considered to be that of a breeding pair from the current season (and hence included in the projected estimate of number of breeding pairs) (also see Ogden 1979). For each tree, estimates of tree height, lowest and highest nests were made by projecting upwards from a ground-2 metres reference height. Trees were scored as being exposed (on the edge of the island) or protected (on the inner parts of the island or protected by other vegetation), mature (with fruits) or immature (without fruits). Up to ten estimates of internest distance were recorded in each species of tree/shrub. During the study period, any intra-specific interactions between adult birds on adjacent nests were noted. Where there was only one nest in a tree/shrub, it was treated as the 'highest nest'. Where nests occurred only on the leeward side of exposed trees/shrubs, these nests were classed as 'sheltered'. To compare with other studies, dead chicks were counted to determine whether the sticky fruits of *P. grandis* contributed to any deaths.

TABLE 2

Projected totals of Black Noddy nests in tree/shrub species selected and actual inter-nest distances measured in sample quadrant, Lady Elliot Island.

Tree/shrub	Total nests	Mean distance ± SD (m)	[n]	(Range) (m)
Casuarina equisetifolia	18 787	0.58 ± 0.42	[155]	(0.2-5.0)
Heliotropium foertherianum	7807	0.46 ± 0.2	[213]	(0.1-1.5)
Pisonia grandis	2147	0.71 ± 0.4	[133]	(0.3-2.2)
Pandanus tectorius	320	0.75 ± 0.43	[102]	(0.2-2.0)
Ficus opposita	94	0.52 ± 2.43	[41]	(0.2-1.3)
Terminalia arenicola	26			
Hibiscus tiliaceus	24			
Araucaria cunninghamii	8			
Lantana camara	3			
S. actinophylla	1			
TOTAL	**29 217**			

From an aerial photograph (taken November, 2011), it was possible to identify the different tree species used for nesting on the island and ground truthing confirmed this. The outlines of each of *C. equisetifolia, H. foertherianum* and *P. grandis* were cut out for the southeastern quadrant and the rest of the island. The weights of these were measured using an Adam Equipment™ analytical balance (accurate to 0.0001g). Projections of the season's nests in each of these species for the whole island were made by algebraic calculations from the known totals in the south-eastern quadrant. Absolute nest counts were obtained for *C. nucifera* (that only occurred in the south-eastern quadrant) as well as *F. opposita, L. camara, Schleffera actinophylla, H. tiliaceus*, *Araucaria cunninghamii*, *Terminalia arenicola* and *P. tectorius* because all individuals of these species could be searched for nests.

Where appropriate, statistical tests were carried out using *Excel* in Microsoft Office 2007. Only significant differences ($P<0.05$) are reported unless comparing with other studies. Observations following a major storm event affecting the island a month prior to the study were obtained from Ryan Jeffery (pers.comm.).

RESULTS

The stages of breeding of Black Noddies ranged from nest-building to fledged young that remained within the nest tree, frequently close to an unoccupied nest. Only one dead chick was found, hanging from a *P. grandis* twig but not in contact with any fruits. In the month prior to this study high winds knocked many chicks from nests (7–8 December, 2011, cyclonic winds to 48 knots; 24–25 December, 2011, winds to 25 knots, sea 3–4 m swell). Staff on the island replaced fallen chicks onto remaining nests and observed adults feeding more than one young (Ryan Jeffery pers.comm.). It is not known whether any nesting activity during the study period was due to re-nesting following failure resulting from the December storms.

On plants with nests, few had only one nest per tree/shrub: *C. equisetifolia* (*n*=8); *Cocos* sp. (*n*=3); *H. foertherianum* (*n*=3); *P. grandis* (*n*=1). Trees were mature with the exception of *C. nucifera*, in which about half of the immatures had nests, and *P. tectorius* with none of the immature trees (about a quarter) having nests (Table 1). The highest number of nests per tree/shrub was in *P. grandis* (45.2), followed by *F. opposita* and then *H. foertherianum* with the lowest in *C. nucifera* (5.9) (Table 1). Almost all nests had an adult sitting (89–100%) (Table 1), the remainder had a juvenile bird nearby. Only *C. equisetifolia*, *H. foertherianum* and *P. tectorius* occurred in exposed and protected locations: more nests occurred in protected trees/shrubs than exposed (Table 1). There was no relationship between the heights of plants and the height of nests. In *C. equisetifolia,* higher trees contained more nests (Pearson's $r=0.31$, $p=0.01$).

Nests were closest together in *H. foertherianum.* Distances between nests varied with the habit of the tree/shrub with large standard deviations about the mean for all trees/shrubs (Table 2). During the study period (daylight hours), there was no intra-specific interaction between adult birds on adjacent nests at any of the sites.

Nests were found in ten species of tree/shrub but, from the projection calculations, most were in *C. equisetifolia,* then *H. foertherianum* and *P. grandis* (Table 2). A total of 29, 217 nests was projected, indicating the same number of breeding pairs of Black Noddies.

DISCUSSION

Black Noddies breed from October to March with most chicks present from December to February on Heron Island (Kikkawa 1970). Given the relatively close proximity of Heron Island, it is likely that the breeding period is similar on Lady Elliot Island so that the estimate of the number of breeding pairs found during this study represents a satisfactory estimate of the total. It is possible that the projection is an over-estimate compared with Heron Island because of the effect of the storms reported for December 2011 but fragmented nests were not included in this study.

The findings from this study confirm those of Walker (1989) who found that Black Noddy nests were mostly in *C. equisetifolia* followed by *H. foertherianum* though his estimate of the cover of *C. equisetifolia* (about half the cay) was found to be lower (36%). The higher cover of *C. equisetifolia* estimated in this study may be due to rehabilitation and natural regrowth in the intervening period. Walker did not describe his method for determining the number of nesting birds. His comment 'thousands roost in trees at night during summer' suggest a large pool of potentially breeding birds at that time and may partially account for the increase in nests he reported following the first count in 1985–6. This study's findings contrast with those on

Heron Island where *C. equisetifolia* and *P. grandis* were under-utilised as nest sites despite them being the dominant tree species; *F. opposita* was also little utilised on Heron Island (Barnes and Hill 1989). The differences may be attributable to the vegetation history of Lady Elliot Island where *C. equisetifolia* was planted extensively during the re-vegetation that commenced in 1969. On Heron Island, 75 per cent of nests were in *P. grandis.* Given the nesting densities in *P. grandis* and *F. opposita* on Lady Elliot Island, it is possible that if weeds were controlled to give these species a better chance to regenerate, numbers of breeding birds could continue to increase, particularly in *P. grandis*. Although agonistic intraspecific interactions can occur between adults during the establishment of nest sites (Higgins and Davies 1996 and references there-in), the variation in internest distances and lack of intraspecific interaction between adults at nest sites suggests that distances between nests, once sites are established, are a function of the habit of the tree/shrub rather than behavioural mechanisms.

It is possible that breeding adults were lost during the cyclone though Ogden (1993a) suggests that this appeared to average one per cent per annum. If this is the case, the estimate of breeding pairs in this study is probably an under-estimate and the number of breeding pairs could be approaching 30 000. In the far northern region of the Great Barrier Reef, Black Noddies were found to nest during ten months of the year with peaks in April, July and November but population counts fluctuated (Blaber *et al.* 1998). This may be a tropical phenomenon and contrasts with the southern region of the Great Barrier Reef where numbers of breeding pairs increased on Heron Island over a 75-year period, apart from the 1992 dip (Ogden 1993b), until 2000 (Dyer *et al.* 2005) and on Lady Elliot Island over a 25-year period. Barnes and Hill (1989) demonstrated an approximately exponential increase in the Black Noddy nesting population over 75 years on Heron Island despite major differences in survey techniques; Dyer *et al.* (2005) suggest that the decrease during 1997–98 and 1998–99 may be cyclical. Barnes and Hill (1989) found that the density of Black Noddy nests was similar in the developed and un-developed areas of Heron Island. The developed area is small on Lady Elliot compared with Heron Island but ground truthing suggested that the densities were similar elsewhere on Lady Elliot to the area sampled supporting the method used in this study. A weakness of this study is the short period over which it was conducted and it is recommended that future estimates of breeding populations are carried out for longer periods or there is an increased number of visits (see Walker 1989). For more meaningful comparisons to be made between breeding populations in the same geographic location, for example, the southern Great Barrier Reef, methods for estimating populations should be standardised.

It is recommended that there is active weed control in the inner parts of the Island and that more *P. grandis* forest is developed to reflect the natural vegetation patterns of coral cays in the region. Despite the number of native coral cay species staying roughly constant for 100 years, Batianoff (1998) found that they decreased by about 17 per cent from 1988 to 1997 on Lady Elliot Island and that about 40 per cent of the island was covered by the woody species *L. camara* and *Bryophyllum tubiflorum.* Reversing this trend and replacing weeds with flora that provide secure breeding sites will enhance the opportunities for the number of breeding pairs on the Island to increase in the future.

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