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BURROW OCCUPANCY BY WEDGE-TAILED SHEARWATERS AND FLESH-FOOTED SHEARWATERS ON LORD HOWE ISLAND

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In January 2001 burrow occupancy for two species of Shearwater *Puffinus carneipes* and *Puffinus pacificus* was ascertained by using a burrowscope to inspect burrow contents at various sites on Lord Howe Island. Burrow occupancy (and burrow lengths) for *Puffinus carneipes* and *Puffinus pacificus* averaged 60 per cent (1.4 m) and 57 per cent (0.8 m) respectively. Neither burrow density nor the amounts of litter covering burrow entrances were good indicators of burrow occupancy.

INTRODUCTION

There are few details of the actual breeding success for either of the Shearwaters that breed in summer on Lord Howe Island. This paper provides initial information, as observed in late January 2001, regarding burrow occupancy, litter covering burrow entrances, and burrow length, at the incubation/hatching stage of the breeding cycle for Flesh-footed Shearwaters *Puffinus carneipes* and Wedge-tailed Shearwaters *Puffinus pacificus* in various habitats.

Lindsey (1986) reported a breeding population of 60 000 Wedge-tailed Shearwaters and Fullagar and Disney (1981, in Marchant and Higgins 1990) reported 20 000 to 40 000 Flesh-footed Shearwaters on Lord Howe Island. The Flesh-footed Shearwater, nesting in colonies that cover 46 hectares, is 'now restricted to lowland forest areas round settlement, mostly in palm forests along the e. side from Ned's Beach, S to Transit Hill; also Old Settlement Bay' (Marchant and Higgins 1990 p.611). Wedge-tailed Shearwaters nest on the off-shore islets including the Admiralties, Muttonbird Island, Blackburn Island and on Balls Pyramid, with smaller colonies occurring on the main island at New Gulch, Muttonbird Point, Hells Gate, Windy Point, Lovers Bay and Signal Point (Hutton 1991).

Both species return to Lord Howe Island in late August/early September and have very similar breeding cycles that last until adults depart in May. They both breed in dense colonies, nesting in forested or open areas with density depending on substrate (Marchant and Higgins 1990) and soil strength (Neil and Dyer 1992). They sometimes breed in mixed colonies with other shearwater and/or petrel species (Marchant and Higgins 1990).

It is with some difficulty that Shearwater breeding success is monitored. In fact, details of burrow densities, incubation period, and breeding success for the Flesh-footed Shearwater are 'poorly known' (Marchant and Higgins 1990 p.614). In the past, inaccessibility or length of burrows has failed to be discussed (Sinclair 1981). The use of a 'burrowscope' avoids much of the error associated with indirect and relatively superficial observations that have been used previously to establish burrow occupancy for burrowing birds (Dyer and Hill 1991).

The burrowscope, developed specifically to ascertain burrow occupancy of Wedge-tailed Shearwaters, consists of a black and white miniature video camera connected to an external monitor. Utilizing infra-red light to minimize disturbance to birds, the camera is inserted inside burrows and an image of the contents of dark burrows is relayed to the monitor screen that is placed at the burrow entrance (Dyer and Hill 1991; Dyer and Aldworth 1998).

METHODS

At four Flesh-footed and two Wedge-tailed Shearwater breeding sites, 10 metres × 10 metres observation plots were set up. All burrows in the plots were inspected with the burrowscope. Where burrow density was low, if the first plot did not contain a minimum of 30 burrows, all burrows in a second, and in one case a third, 100 square metre plot were inspected (Table 1).

The entrances of Flesh-footed Shearwater burrows are often 'choked by vegetation, apparently hauled in by the birds themselves', choked burrows being more likely to be occupied (Lindsey 1986 p.275). Accordingly, the proportion of burrow entrances covered by vegetation (<20%, 20–80%, and >80%), details of burrow occupancy, and burrow length were recorded for each burrow. The proportion occupied for those burrows that could be reached by hand (those up to 0.75 m in length) was compared with the proportion for those that could not (>0.75 m). This is essential to ascertain whether or not burrow colony occupancy rates can be reliably inferred by extrapolating data from the examination of short burrows only.

The contents could not be ascertained for all burrows inspected because of the limitations of the burrowscope. For instance, some burrows were too convoluted to allow the head of the burrowscope to be manipulated so that all burrow contents or the full length of the burrow was visible. Some adults are reluctant to show whether or not they are sitting on an egg or have a chick. Such cases, where there was some doubt about the observations, were omitted from the analyses (see Table 2).

RESULTS

Burrow occupancy

Burrow occupancy appeared not to be influenced by burrow density (Table 2). The range of burrow density, though, was higher across the four Flesh-footed Shearwater sites (0.09/m^2 to 0.71/m^2) than for the two Wedge-tailed Shearwater sites (0.20/m^2 to 0.32/m^2).

TABLE 1

Location of study sites showing plot size and date of observation.

Site	Lat/Long	Micro-Habitat	Plot Size	Date
		Puffinus carneipes		
Clear Place	Not Available	Palm Forest	(1 × 100 m² plot)	27.01.2001
Middle Beach	S31.52505 E159.07447	Forest	(2 × 100 m² plot)	22.01.2001
Neds Beach	S31.51946 E159.06502	Palm Forest	(2 × 100 m² plot)	25.01.2001
Old Settlement Beach	S31.52014 E159.05799	Palm Forest	(3 × 100 m² plot)*	23.01.2001
		Puffinus pacificus		
Signal Point	S31.52488 E159.06000	Steep Grassed Slope	(2 × 100 m² plot)	26.01.2001
Windy Point	S31.53384 E159.06943	Grassed Knoll	(2 × 100 m² plot)	23.01.2001

* Four burrows from outside the 300 square metre plot were inspected in order to make up N = 30.

The timing of the research coincided with the start of the Flesh-footed Shearwater hatching period. No chicks had hatched in the plot inspected at Middle Beach on 21 January whereas, by 27 January, 44 per cent of burrows inspected at Clear Place housed an adult bird with a chick or an unattended chick (Table 2). At this site only 17.5 per cent of burrows still contained incubating birds. The chicks were obviously only two to three days old, two were still damp and in one burrow, a chick's bill was protruding through the eggshell at the time of inspection. The Wedge-tailed Shearwaters' breeding stage appeared to be slightly more advanced. By 22 January, all adults in the colony at Windy Point had already left their chicks unattended, and only 10 per cent of chicks in the vicinity of Signal Point were still attended by adult birds on 25 January.

Burrow occupancy for Flesh-footed Shearwaters, based on the number of burrows with an adult, egg, and/or chick, ranged from 58.1 per cent of burrows at Middle Beach to 63.6 per cent at Clear Place. Since this is the first published record of its kind for Flesh-footed Shearwaters, it is not known how this outcome compares with other colonies nor whether there has been any change over time.

Occupancy of Wedge-tailed Shearwater burrows was found in 58.5 per cent of burrows at Windy Point and in 54.9 per cent of burrows at Signal Point. These burrow occupancy rates exceed those observed on southern Queensland islands (37% in late January 1997 on Mudjimba Island (Dyer 1999a) and 24 per cent in late December 1989 on North Stradbroke Island (Dyer and Hines 1994)). They are relatively similar to burrow occupancy rates on Great Barrier Reef Islands (58% in December 1995 on Raine Island (Dyer 1999b), and 43, 49 and 50 per cent in December 1989, 1990 and 1993 respectively, on Heron Island (Hill *et al.* 1996). As with the Flesh-footed Shearwater it is impossible to ascertain whether there has been any change in burrow occupancy over time on Lord Howe Island.

Entrance cover

Significant differences (χ^2 = 19.759, df = 6 p, = 0.003, N = 173) between sites were found in the degree of cover over entrances of Flesh-footed Shearwater burrows. The burrows in the rain forested area of Middle Beach, were most likely to have cleared entrances with 75.7 per cent of burrows being less than 20 per cent covered. No burrows at this site had greater than 80 per cent entrance cover whereas between 11 per cent (Clear Place) and 25 per cent (Neds Beach) of burrows had greater than 80 per cent coverage at other Flesh-footed Shearwater sites. The other anomaly noted from the cross tabulation was that, at the Neds Beach site, more burrows than expected under random conditions fell within the 20–80 per cent coverage range. Contrary to expectations there was no significant relationship between entrance coverage of Flesh-footed Shearwater burrows and occupancy (χ^2 = 4.416 df = 2 p = 0.110 N = 168).

No significant difference in entrance cover was found between the two Wedge-tailed Shearwater sites (χ^2 = 1.272 df = 2 p = 0.529 N = 105) with approximately 55 per cent of burrows having 20–80 per cent entrance cover and approximately 30 per cent of Wedge-tailed Shearwater burrows having cleared entrances. No significant relationship was found between Wedge-tailed Shearwater burrow occupancy and entrance cover (χ^2 = 0.748 df = 2 p = 0.688 N = 105) on Lord Howe Island.

TABLE 2

Burrow density and occupancy rates for Flesh-footed and Wedge-tailed Shearwaters at different sites on Lord Howe Island.

Site Species	N (Valid)	Burrow Density	Adult No. Egg/Chick %	Adult With Egg %	Adult With Chick %	Egg No. Adult %	Chick No. Adult %	Occupied Burrows
			Puffinus carneipes					
Clear Place	71 (63)	0.71/m²	1.6*	17.5	27.0	0.0	17.5	63.6%
Middle Beach	37 (31)	0.18/m²	6.4	48.4	0.0	3.2	0.0	58.1%
Neds Beach	35 (32)	0.17/m²	6.2	37.5	9.4	0.0	6.3	59.4%
Old Settlement Beach	30 (26)	0.09/m²	7.7	34.6	7.7	3.8	7.7	61.5%
			Puffinus pacificus					
Signal Point	64 (62)	0.32/m²	0.0	11.3	9.7	0.0	33.9	54.9%
Windy Point	41 (41)	0.20/m²	2.4*	9.8	0.0	2.4	43.9	58.5%

* 2 adults, no egg, in one burrow.

Length of burrows

There is little difference in the range of lengths between Flesh-footed and Wedge-tailed Shearwater burrows (a 3 m Wedge-tailed Shearwater burrow having been observed on North Stradbroke Island). On Lord Howe Island, however, Wedge-tailed Shearwater burrows are on average about half a metre shorter than Flesh-footed Shearwater burrows ($F = 4.43$, $p = 0.03$) (see Table 3).

TABLE 3
Burrow lengths of Flesh-footed and Wedge-tailed Shearwater burrows at different sites on Lord Howe Island.

Site	N	Minimum (m)	Maximum (m)	Mean	Std. Deviation
Puffinus carneipes					
Clear Point	69	0.20	2.00	1.21	0.44
Middle Beach	36	0.20	2.50	1.27	0.56
Neds Beach	34	0.20	2.75	1.29	0.59
Old Settlement Beach	30	0.50	3.00	1.70	0.60
All Sites	169	0.20	3.00	1.32	0.55
Puffinus pacificus					
Signal Point	64	0.20	2.30	0.81	0.47
Windy Point	41	0.20	1.65	0.86	0.38
All Sites	105	0.20	2.30	0.83	0.44

Flesh-footed Shearwaters are more likely to nest in burrows that cannot be reached by hand ($\chi^2 = 25.886$ df $= 1$ $p = 0.000$ $N = 166$). Only 17.5 per cent of Flesh-footed Shearwater burrows were short (up to 0.75 m) and only 24.1 per cent of these were occupied compared with the 73.7 per cent of the longer burrows (>0.75 m) that were occupied. The difference in Wedge-tailed Shearwater occupancy between short and long burrows was not statistically significant ($\chi^2 = 2.179$ df $= 1$ $p = 0.140$ $N = 105$). Even so, only 35.6 per cent of the longer Wedge-tailed Shearwater burrows were unoccupied.

DISCUSSION

In this study, the amount and type of litter available for covering burrow entrances was aligned with habitat for Flesh-footed Shearwaters. Even though burrow occupancy does not appear to rely on this activity, some birds appear to purposefully cover their burrow entrances. This fact alone is sufficient to imply that, where burrowing species occur near housing as at Lord Howe Island, some litter should be left for birds to use.

The findings here do not support Lindsey's (1986) conclusion that burrows that have their entrances choked with litter are more likely to be occupied. Rather, it confirms that degree of entrance cover (whether cleared or covered) is not a reliable indicator of burrow occupancy for either Wedge-tailed or Flesh-footed Shearwaters. Therefore this indicator should not be used for burrowing species unless thoroughly tested for the particular species concerned.

Although both species of summer-breeding Shearwaters have been seen on the ground at night in the vicinity of Neds Beach (Hutton and O'Neill, pers. comm.), no Wedge-tailed Shearwaters occupied any of the 35 burrows inspected there. It appears that, while the species may roost in mixed colonies on Lord Howe Island, further investigations are needed to establish whether or not they nest in mixed colonies.

Burrows for both species on Lord Howe Island were found to be longer than previously reported: Flesh-footed burrows of 1–2 metres long (Marchant and Higgins 1990) and Wedge-tailed Shearwater burrows up to 1metre long (Hutton 1991). The average and maximum lengths of burrows as reported here are minimal, as it was impossible to reach the chamber in some burrows because they were longer than could be observed effectively with the burrowscope.

Without replication over time the findings of this study are limited. However, publishing these findings with specific sites identified at least allows for replication by others at a later date. If this happens the value of this baseline data could be realized.

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