Short Communications

An Integrated Mapping Approach to Monitoring Burrowing Birds: Wedge-tailed Shearwaters on North Stradbroke Island, Queensland

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At Point Lookout, on North Stradbroke Island, Queensland, (approximately 50 km from Brisbane), a small colony of Wedge-tailed Shearwaters *Puffinus pacificus* was first recorded in 1983 at the north and south headlands near Dune Rocks. In the 1990-91 season this young colony included 248 burrows that had surface level signs of recent activity. Although no colony existed there in the early 1970s (A. Smyth pers. comm.) some birds occupied the Point Lookout headland, a kilometre further south, in the early 1950s (J. Woodward pers. comm.). The eight burrows found there in November 1987 (B. Hines pers. comm.) may be all that remain of that colony.

At both the north and south headlands near Dune rocks there are natural boundaries that preclude burrowing by birds. The study site is situated within the vegetated area on the north headland which is bounded in the east and south by cliffs, and in the north and west by sand hills where the sand is too loosely packed to support surface digging. Within the study site, two main vegetation types exist. On a gentle west to east falling slope, the northern section consists of herbs and grasses with some *Banksia* sp. The steeper north to south slope in the southern section has a surface layer of grass with a canopy cover of *Casuarina* sp.

Because no details about Wedge-tailed Shearwater

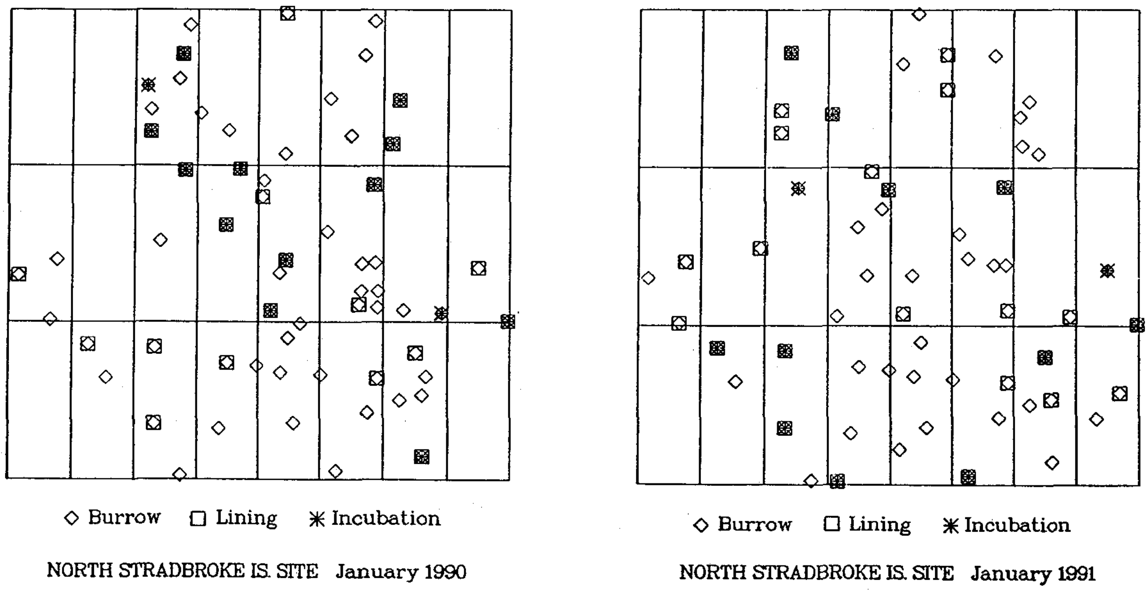

Figure 1 Distribution of burrows within the North Stradbroke Island study site (2 x 5 m quadrats), January 1990 and January 1991, showing those burrows that contained chamber lining and/or incubation.

breeding habits at Point Lookout are known, an attempt was made to establish burrow status and burrow patterns, and to test a method for monitoring burrows, so that the necessity for (and direction of) future research could be considered. This paper describes the results of this work and the development of an integrated mapping approach which facilitated spatial analyses of the burrow data.

Methods

Data were collected during the 1989–90 and 1990–91 breeding seasons. Burrows at surface level within a marked grid constituting 200 m^2 and consisting of 2 x 5 m quadrats were mapped. Fixed points such as well established trees were noted to simplify repetitive mapping of the same area in subsequent seasons. The status of each individually identified burrow was recorded with the aid of a burrowscope which allows the viewing of contents of burrows with minimal disturbance (Dyer & Hill 1991).

A combination of Autocad (1988), dBase (1990) and MapInfo (1991) was used to integrate spatial information and data concerning burrow status. Autocad was employed for initial recording of the grid and burrow map which were then transferred to MapInfo. MapInfo has the capacity to integrate maps and data. dBase and mBase were used interchangeably to record data because dBase has more powerful facilities for data manipulation. This manipulation enabled measurement of nearest neighbour distances by comparing 'x' and 'y' coordinates of fixed points which represented burrows on the grid. Means of these nearest neighbour distances were established and nearest neighbour analyses performed (Taylor 1977).

Results

Figure 1 displays the distribution of vacant, occupied and/or lined burrows in the study area for both seasons. This figure exposes a relatively low burrow density ($0.4/m^2$) and rate of burrow usage for breeding purposes with only 22% and 24% of burrows accommodating incubating birds in the 1989–90 and 1990–91 seasons respectively. Although only half the lined burrows supported incubating birds there was a strong relationship between incubation and the occurrence of burrow lining (lining of the nesting chamber with grass) with 92% of incubation burrows lined in both seasons (Fig. 1).

By filtering and overlaying the information for both

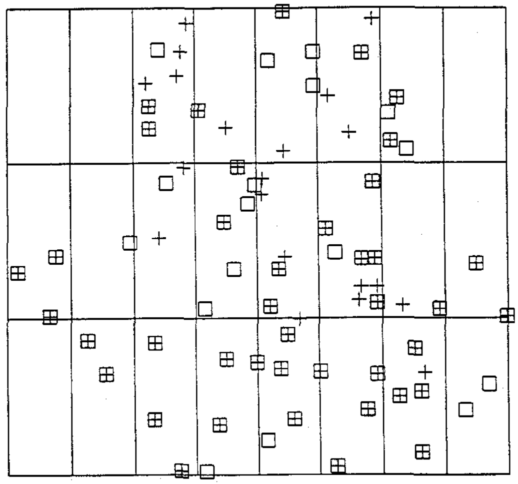

Figure 2 The distribution of burrows showing burrow retention between January 1990 and January 1991.

seasons on the same grid (Fig. 2), a measure of burrow stability is readily discerned. In the 1990-91 season, 45 of the 61 burrows examined in the 1989–90 season remained intact. Those burrows in the southern section, that has a canopy cover of *Casuarina sp.*, were more stable than those in the more exposed northern section of the study area ($\chi^2 = 9.095$, *d.f.* = 1, $P < 0.01$).

Similarly, by overlaying the burrows in which incubation occurred in both seasons on the grid (Fig. 3) the lack of consistent use of the same burrow over time becomes apparent. Only two of the 13 burrows which supported incubation in the 1989–90 season were reused in the subsequent season.

Because of heavy rain in the area during the day before the March 1991 observations, new overnight footprints in burrow entrances were able to be recorded (Fig. 4). These burrows were not necessarily those associated with earlier incubation. In fact, only four of the 13 burrows that had contained incubation in January acquired fresh footprints during that night. That the number of active burrows had increased to 79 when only one chick remained in the study area, just before the birds vacated the colony, indicates that burrowing activity had increased.

For each visit to the Dune Rocks site, significant,

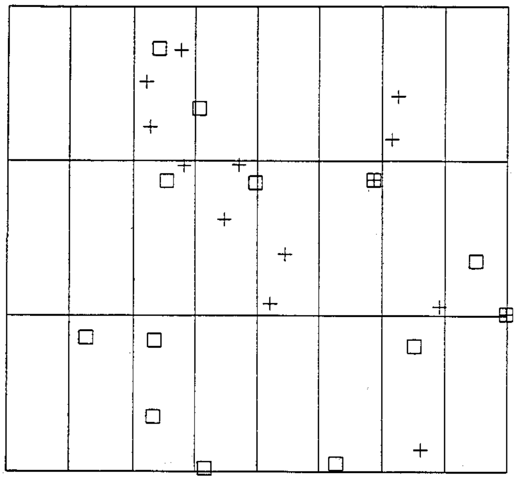

Figure 3 Distribution of burrows containing incubating birds in January 1990 and January 1991.

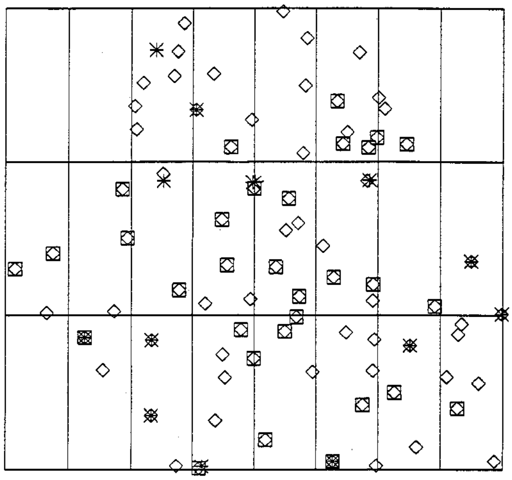

Figure 4 Distribution of burrows that had acquired fresh footprints overnight in March 1991.

slight to moderate dispersed patterns were revealed by nearest neighbour analyses when all burrows were assessed. No significant spatial patterns were found when only those burrows which supported incubation were considered (Table 1). The integrated mapping method, however, revealed patterns of incubation in burrows located in the northern section of the study area in the 1989–90 season but a more even distribution throughout the study site in the 1990–91 season (Fig. 1).

Discussion

The integrated mapping method introduced here compares favourably with that of examining the contents of marked burrows because all burrows within the study area are monitored each season. Although some burrows are lost or damaged, the census approach reflects the use of the area rather than the degree of burrow stability. When marked burrows are examined, the reduction in sample size between seasons reflects burrow stability rather than the degree of usage by birds. Unless new burrows are marked each season the sample is eventually depleted or rendered too small for analytical purposes. Both burrow stability and degree of usage by birds can be appraised in the integrated mapping method because stable burrows can be identified by location, new burrows added, and disused burrows removed when the map is updated each season. The stable burrows allow for monitoring of the same burrows over time. Increased or decreased attractiveness of the site in relation to the overall colony and/or other colonies can also be assessed.

By incorporating point pattern analyses with integrated mapping, spatial analyses support visual representation of the actual patterns. Spatial analyses alone (such as nearest neighbour analyses of unmapped data) reflect a degree of pattern and pattern type, but not the way points are distributed within that pattern (Hammond & McCullagh 1974; Bartlett 1975; Taylor 1977; Ebdon 1985). By combining integrated mapping and nearest neighbour analyses, the likelihood of overlooking a pattern or misinterpreting the influence of a pattern due to its type, is minimised. This combined approach covered both dispersion and regularity components of burrow layout as described by Cole & King (1968).

This study exposed low incubation rates (proportion of burrows supporting incubation) when compared with other larger colonies such as those in the Capricorn Group, on the Great Barrier Reef (approx. 50%, Dyer & Hill 1992). Whilst the sample was small, expected nest-site tenacity suggested by Roughley (1936), Lockley

Table 1 Results of nearest neighbour analyses, which measure the type and degree of pattern of dispersal, for burrows within the North Stradbroke Island study site.

Visit	*n* all burrows	*n* incubation burrows	Area	RA	R	ZR	*P*
Nov. 1989	13	—	40	1.09	1.243	1.67	0.047
Nov. 1989	—	4	40	1.12	0.708	0.72	0.236
Jan. 1990	61	—	200	1.13	1.248	3.71	< 0.001
Jan. 1990	—	14	200	1.88	0.995	0.41	0.341
Jan. 1991	62	—	200	1.29	1.436	6.57	< 0.001
Jan. 1991	—	13	200	2.63	1.341	0.18	0.429
Mar. 1991	79	—	200	1.00	1.257	4.37	< 0.001

Random Factor R: actual mean neighbour distance (RA)/expected mean neighbour distance (RE), where RE = $1/(2\sqrt{(\text{Number/Area})})$. The random factor R ranges from 0 (aggregated in a single location) through 1 (random) to 2.149 (even dispersion in triangular lattice pattern). Variance of significance ZR: absolute (RE–RA, standard error of RE). *P* = probability.

(1942), Gross et al. (1963), Perrins et al. (1973), Brooke (1978), Simons (1985) and Fullagar (1988) was not supported.

Burrow density on North Stradbroke Island was much lower than in some areas in the Capricorn Group, such as North West Island where densities of up to $2.0/m^2$ are found (Dyer unpub. data). There is no apparent reason for this lower density or lesser congregation of burrows within the Dune Rocks colony. Social influence, which may be involved in the congregated patterns on Heron and Masthead Islands where burrow densities can be as low as $0.04/m^2$ (Dyer & Hill 1990), may not have had time to develop in this young colony. Alternatively, the colony is compact and restricted by natural boundaries with sufficient social intercourse provided by a confined area. Varying types of dispersion, at different locations and within relatively similar habitat types, contradict Nelson's (1980) observation that similar spatial patterns are maintained between different colonies, regardless of population size. General density, rather than population size may be the criterion that should be considered for burrowing species, particularly the Wedge-tailed Shearwater.

The method used here provides a visual aid for interpreting spatial data and presenting inter-season comparisons. The difference between 1989–90 and 1990–91 would not be so obvious by using alternative methods which did not support the filtering and overlaying of seasonal data. The combined method is also suitable for opportunistic research as when rain washed away footprints the day before data were recorded in March, invalidating the assumption that burrows with signs of activity, such as footprints, are used by breeding birds (e.g. Shipway 1969; Jahnke 1975; Kikkawa & Boles 1976; Ogden 1979; Hulsman 1984; Hill & Barnes 1989; Hill & Rosier 1989; Walker & Hulsman 1989; Dyer & Hill 1990; Neil & Dyer 1992).

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The Decline of the Black Treecreeper *Climacteris picumnus melanota* on Cape York Peninsula

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The Black Treecreeper *Climacteris picumnus melanota*, the northern subspecies of the Brown Treecreeper, occurs from the Burdekin–Einasleigh divide northwards up Cape York Peninsula (Ford 1986). In the southern part of its range, from the Atherton Tablelands west to the Gulf of Carpentaria, it is still reasonably common, having been recorded during the period 1977–81 in 18 of about 21 possible one degree squares (Blakers *et al.* 1984). To the north, however, it was reported during the same period in only three of a possible 15 squares, all of which were near Weipa in the north-western part of the Peninsula. While Weipa was the area of greatest observer effort, sites in the centre of the Peninsula were visited almost as frequently (Blakers *et al.* 1984) and the Edward River region on the west coast was surveyed thoroughly over a period of two years (Garnett & Bredl 1985).

The apparent scarcity of Black Treecreepers through much of the Peninsula contrasts with observations earlier in the century. In October and November 1922 W.