Short Communications

An Artificial Nest Box For Burrow-Nesting Seabirds

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An artificial nest box for burrow-nesting seabirds (Fig. 1) was developed to enhance population recovery of the rare and endangered Gould's Petrel *Pterodroma leucoptera leucoptera*. The nest box has application worldwide. It can be used to supplement available nesting habitat, to provide nest sites that offer both protection from predators and shelter from adverse weather, or to provide secure refugia. It can also improve substantially the ease of studying burrow-nesting seabirds.

Artificial nest boxes have been used to study the breeding biology and habits of many species of bird, particularly those that nest in tree hollows. The technique facilitates observation as well as providing access to nest chambers which would otherwise be inaccessible. Artificial nest structures have been used successfully in the study and management of several species of burrow-nesting seabird; for example, Bermuda Petrels *Pterodroma cahow* (Wingate 1978); Wedge-tailed Shearwaters *Puffinus pacifcus* (Byrd 1979; Byrd & Brady 1983); and Little Penguins *Eudyptula minor* (Reilly & Balmford 1971, 1975; Klomp et al. 1991). Although Little Penguins can excavate extensive burrows they also nest under natural and artificial structures (Meathrel & Klomp 1990) and readily take to nest boxes placed on the surface.

Some burrow-nesting seabirds have been studied by cutting removable earth plugs from above the nest chamber (e.g. Johnson & Davis 1990). This technique is less than satisfactory because soil usually falls into the chamber during each inspection and water inevitably percolates through to the nest chamber and thereby jeopardises breeding success (Warham 1990). Another method used has been to replace the natural nest chamber with nest boxes fitted with viewing facilities (Warham 1966). Petrels (Order: Procellariifomes) take readily to appropriately sized nest boxes as artificial nest chambers, provided the entrance tunnel remains undisturbed (Warham 1990).

This paper details the design of a nest box that comprises both nest chamber and entrance tunnel, and which can be buried. Although designed specifically for a cavity-nesting seabird, it is equally suitable for burrow-nesting species.

Description of the nest box

The nest box, without entrance tunnel, measures 200 x 250 x 520 mm in length, width and depth (Fig. 1). Internally, it comprises two cavities separated by a removable divider. The lower cavity is the nest chamber; the upper cavity provides a repository for monitoring or telemetric equipment, such as data recorders, time-lapse cameras or video recording equipment. *In situ* the box can be partially buried, up to a depth of 500 mm, with only 20 mm protruding above ground. A removable lid provides easy access from above, while the depth of the box ensures that the occupants cannot escape.

Leading from the nest chamber is a tunnel formed from 100 mm diameter PVC sewer-pipe fittings (Hardie Iplex Pipeline Systems). Three angled (30°) bends (male–female) are connected in series and terminated with a 100-80 mm level invert taper (male-female). Together these components form a tunnel 400 mm long (Fig. 1) whereby the interior of the nest chamber is not visible from the tunnel entrance. The shape and incline of the tunnel can be individually adjusted to suit the terrain at each site (Fig. 2). The natural slope of the ground and additional lengths of pipe can both be used to minimise the incline of the tunnel so as not to impede the passage of birds. To provide traction within the tunnel, the interior surface is coated with coarse grit affixed by contact adhesive.

The use of standard plumbing components allows for the diameter, shape and length of the tunnel to be readily adjusted to suit the profile or habitat requirements of the species targeted. The diameter of the opening of the distal end of the tunnel may be selected to permit ready access to the targeted species and to prohibit entry of larger competitors or predators. An array of various fittings (including invert tapers and socket reducers) is available to reduce the distal opening to a variety of dimensions.

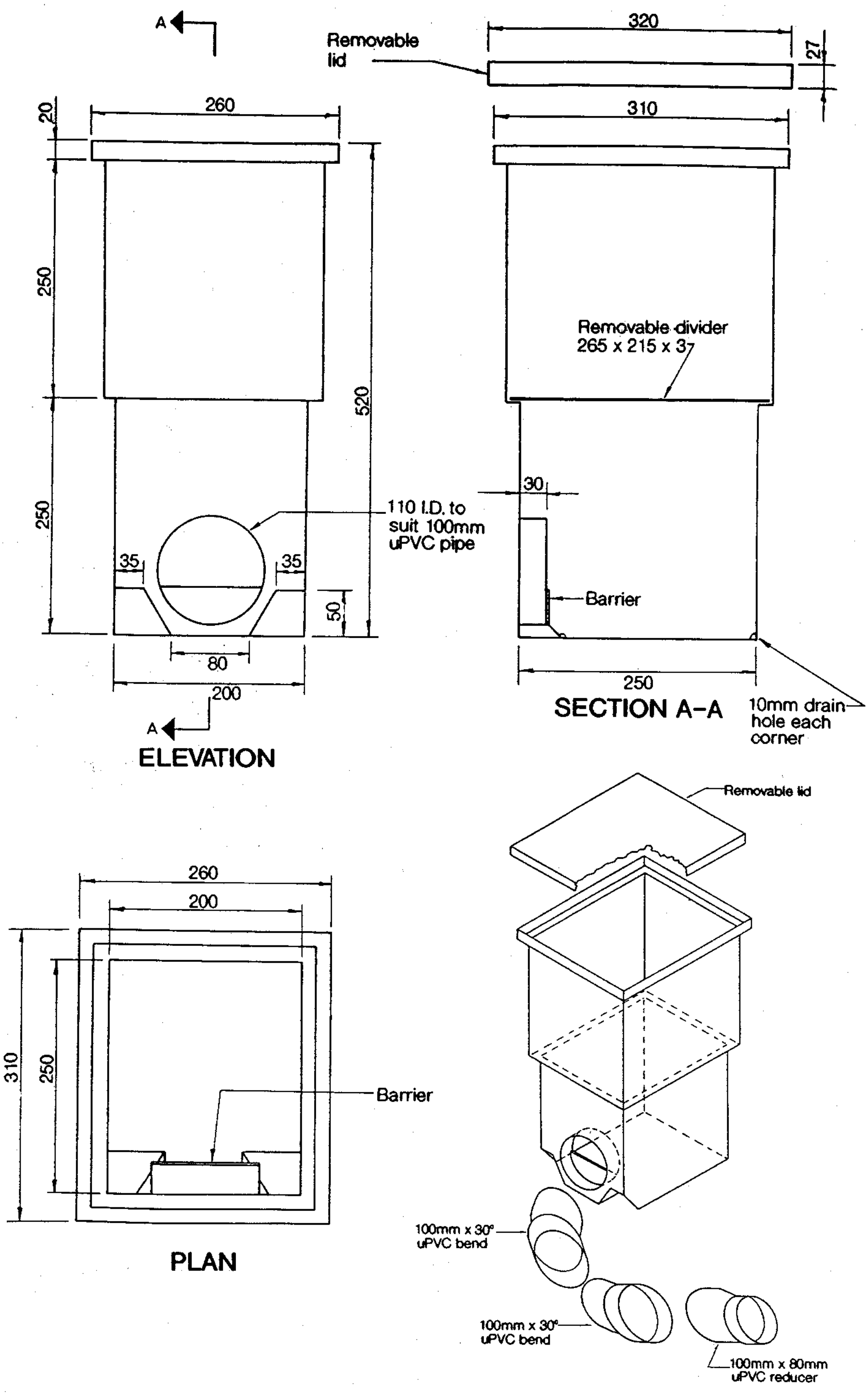

Figure 1 Technical drawings of the nest box showing design specification and dimensions. (Components are shown in exploded view.)

Figure 2 A nest box located within an area previously lacking suitable nesting habitat. The arrow indicates the burrow entrance.

The flange necessary to accommodate the tunnel protrudes into the nesting chamber for a distance of 30 mm (Fig. 1). Either side of this protrusion, the wall of the chamber is chamfered at an angle of 45° to prevent eggs from becoming lodged under the flange. The junction between the nesting chamber and the tunnel is partially blocked by a barrier 40 mm high (Fig. 1). This barrier is essential to ensure that eggs and chicks remain within the nesting chamber. Early prototypes without this barrier suffered some losses when the adults inadvertently pushed eggs or chicks into the tunnel. The barrier does not hinder the passage of adults, or of the chick once it has reached the age of fledging. The presence of the barrier necessitates a small (5 mm) drainage hole to be drilled in the initial pipe component, approximately 25 mm from the proximal end. This prevents water from pooling in the tunnel immediately outside the nest chamber.

A 10 mm diameter hole in each corner of the chamber floor allows for drainage of faecal waste or other fluid that may be deposited in the box while it is occupied. Additional drainage can be provided by drilling holes in the chamber floor. If required, the nesting chamber can be ventilated by drilling a series of small (approximately 5 mm diameter) holes just under the lip supporting the internal divider. Water ingress through the holes during heavy rain is negligible.

The nest box is strong and durable yet relatively light; without the tunnel, it weighs 2.75 kg. With the lid and internal divider removed, the boxes can be stacked, one within another and comfortably carried six at a time. The box is constructed from polyethylene by a manufacturing process referred to as rotational moulding. Polyethylene is chemically inert, relatively inexpensive and can be produced in a variety of colours. The internal divider is made of polyvinyl chloride (PVC). The initial production run of 100 units, including fabrication of the mould, cost around A$4200. If no change to the mould is required, additional units could be produced for around A$36 each. These costs include the box, lid, and internal divider. The cost for components to construct the tunnels is additional (approximately A$23 per unit). The nest box is manufactured by Dex Australia Pty Ltd, Plastics Division, Sydney, Australia, and marketed under the name 'The Down-Under-Box'.

Artificial nest boxes and Gould's Petrel

Gould's Petrels nest in cavities among rock scree, in hollow palm logs and beneath fallen palm fronds (Fullagar 1976); they lack the ability to burrow (Hindwood & Serventy 1941). The species has undergone a 26% decrease in abundance over the past two decades (Priddel et al. 1995). This decline has been due principally to the loss of nesting adults through predation and as a result of entanglement in the sticky fruits of the Bird-lime Tree *Pisonia umbellifera* (Priddel & Carlile 1995). Nest boxes were developed to artificially enhance population recovery of Gould's Petrel now that the control of predators and the removal of hazardous vegetation has been successful in reducing adult mortality (Priddel & Carlile 1995). They were designed to provide nest sites that were secure from predators, protected from adverse weather and free from crevices and protrusions likely to cause loss or breakage of eggs. By eliminating preda-

Table 1 Annual visitation and occupancy of 30 nest boxes installed in each of three habitat types. Data are the numbers of nest boxes visited and the number in which an egg was laid (in brackets). PNH, principal nesting habitat; MNH, marginal nesting habitat; WNH, areas without suitable nesting habitat.

	PNH (n = 30)	Habitat MNH (n = 30)	WNH (n = 30)	All Habitats (n = 90)
1992	12 (0)	25 (0)	11 (0)	48 (0)
1993	10 (5)	14 (6)	9 (3)	33 (14)
1994	(6)	(7)	(6)	(19)

tion at the nest and by reducing the incidence of egg loss due to breakage or chilling, breeding success was expected to increase.

Ninety nest boxes were installed on Cabbage Tree Island (32°42′S, 152°14′E) in August 1992, before breeding began. Thirty boxes were installed within the principal nesting habitat (rock scree containing a labyrinth of crevices); 30 were placed in marginal habitat (areas of soil and rock containing some crevices); and 30 in adjacent areas lacking suitable nesting habitat (areas of soil or rock devoid of crevices). Once in position, the floor of the nest chamber was covered with 5 mm of soil and 10 mm of fragmented dried palm fronds.

A small stick was placed across the entrance to each nest chamber. Dislodgement of these sticks indicated that 48 nest boxes (53%) were visited by Gould's Petrels during the first season (1992) but no eggs were laid (Table 1). Nest site fidelity by Gould's Petrel is high and the selection of nest sites by new breeders appears to occur in the year before breeding begins. Hence, the absence of eggs in the first year is understandable.

During the subsequent breeding season (1993), 33 nest boxes (36%) were visited and 14 pairs took up residence; five within the principal nesting habitat, six in marginal habitat and three in areas previously lacking suitable habitat (Table 1). Fourteen eggs were laid. Six hatched and of these, five fledged. The sixth chick ventured from the nest chamber prematurely and was taken by a predator. Of the eggs that were unsuccessful, one was infertile, one was crushed and six rolled out of the chamber into the tunnel and were subsequently damaged or abandoned. Early prototypes of the nest box did not incorporate the barrier at the proximal end of the tunnel as described in the current design.

Despite the significant loss of eggs due to the absence of a barrier in 1993, the level of reproductive success in nest boxes (36%) substantially exceeds the 23-31% for natural cavities recorded previously (Priddel et al. 1995). These initial data suggest that by providing an artificial nest site that is more secure and less hazardous than natural sites it is possible to increase the breeding success of Gould's Petrel. This finding engenders some optimism that the nest boxes will assist the species to recover to its former numbers.

During the 1994 season 19 eggs were laid in the nest boxes, distributed evenly across all habitats (Table 1). Thirteen eggs hatched and all chicks fledged. The causes of egg loss were not determined. Reproductive success in nest boxes in 1994 was 68%, comparable with that for natural cavities (Priddel unpubl. data). The ubiquitous increase in reproductive success evident in this year was due to the instigation of management practices other than the installation of nest boxes. The additional protection that nest boxes afforded Gould's Petrel in 1993 has since been offset by an intensive program of predator control.

The ready acceptance of the boxes, the high occupancy rate (particularly in areas located outside the principal nesting habitat) and the enhanced or comparable reproductive success, are all very encouraging. Used to create new artificial habitat, nest boxes both expand the current breeding habitat on Cabbage Tree Island and provide opportunities to establish a second colony of Gould's Petrel elsewhere.

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A Comparison of Songs from Four Species of Fairy-wrens (*Malurus*)

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The systematic relationships among the fairy-wrens (*Malurus*) have been inferred from morphological data, mainly male breeding plumages, in concert with distributional and biogeographical information (Schodde 1982). Of the 13 *Malurus* species subdivided into five 'sections', nine species and four of the sections occur in Australia (Schodde 1982; Blakers et al. 1984). Ancillary information from songs has been used to support the groupings of species into the sections of phenotypic similarity (Schodde 1982).

The previous examination of songs from these species lacked instrumental analysis and quantitative comparisons. In a brief pilot study in 1991–92, I tape-recorded four species of *Malurus* belonging to three sections. Here, I present sound spectrograms of these species together with a quantitative analysis of their similarities.

Methods

Tape recording was accomplished with a Marantz cassette recorder (PMD 201) and a Sennheiser microphone (MD 402K) mounted in a 40 cm parabolic reflector. Recordings were analysed with a Kay Elemetrics Sonograph (DSP 5500) and sound spectrograms (sonograms) produced with the Kay 5510 printer. Similarities between spectrograms (Clark et al. 1987; Baker 1993) were calculated using the correlation function of Canary software (v1.1, Cornell Laboratory of Ornithology, Bioacoustics Research Program) implemented on a Macintosh computer. Briefly, the digitised sounds representing two songs are overlapped with one another until the maximum degree of matching is found. This results in a peak value correlation coefficient, which is used as an index to overall similarity in the two songs.