

Occupancy rates and nesting success of European storm-petrels breeding inside artificial nest-boxes*

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SUMMARY: We report on occupancy rates and nesting success of European storm-petrels *Hydrobates pelagicus* breeding in artificial nest-boxes for five years. Plastic nest-boxes were installed inside two natural caves on the island of Benidorm (western Mediterranean), where breeding colonies of the species occur. The location of nest-boxes was (a) over exposed natural nests or (b) at sites without nests, but usually close to them. Nest-boxes were visited during the breeding season following installation, when only nest-boxes over old nests were occupied. Occupancy rates in both types of nest-box increased gradually year after year, reaching 29% in the fifth year. Nesting success of pairs breeding inside boxes was higher than nesting success of pairs breeding at natural sites.

Key words: nesting success, European storm-petrel, *Hydrobates pelagicus*, nest-boxes, occupancy rates, Procellariiformes, Benidorm Island.

RESUMEN: TASAS DE OCUPACIÓN Y ÉXITO REPRODUCTOR DEL PAÍÑO EUROPEO EN NIDALES ARTIFICIALES. – El presente trabajo presenta los resultados de cinco años de seguimiento de las tasas de ocupación anual y éxito reproductor del paíño europeo, *Hydrobates pelagicus*, en nidos artificiales situados experimentalmente en dos cuevas con colonias reproductoras en la Isla de Benidorm (Mediterráneo Occidental). Los nidos de plástico se colocaron bien sobre nidos naturales expuestos, bien en lugares donde no se había registrado anteriormente la existencia de nidos, aunque normalmente cerca de nidos conocidos. Los nidos fueron visitados por los paíños la temporada siguiente a su instalación aunque sólo fueron ocupados los nidos ubicados sobre nidos antiguos. La tasa anual de ocupación ha aumentado en ambos tipos de nidos, alcanzando el 29% en el quinto año. El éxito reproductor de las parejas que criaron en el interior de los nidos fue superior al éxito reproductor de las parejas que criaron en nidos naturales.

Palabras clave: éxito reproductor, paíño europeo, *Hydrobates pelagicus*, nidos, tasas de ocupación, Procellariiformes, Isla de Benidorm.

INTRODUCTION

The European storm-petrel *Hydrobates pelagicus* breeds widely along the European Atlantic coast and throughout the Mediterranean sea, where the subspecies *H. p. melitensis* has been described (Hémery and D'Elbee, 1985; Bretagnolle, 1992; see also Bretagnolle and Zotier, 1998). This subspecies is legally protected (Blanco and González, 1992), and con-

sidered a conservation priority in Spain (De Juana, 1992) and in the autonomous region of Valencia. European storm-petrels are now confined to islets, following human colonisation of the main islands and the introduction of predators (Thibault *et al.*, 1996; Martin *et al.* 2000). Hence, the shortage of adequate nest cavities may affect the local breeding population (Ramos *et al.*, 1997) and breeding site may be one of the limiting factors for storm petrels.

Nest-boxes or artificial burrows have been used in several storm-petrel colonies (Allan, 1962;

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Bolton, 1994, 1996; Ramos *et al.*, 1997). Success has been achieved in re-establishing *Oceanodroma leucorhoa* on islands off the north-eastern United States where these birds formerly bred, using artificial burrows and vocal playback lures (Podolsky and Kress, 1989).

Characteristics and competition for nest sites and their influence on breeding success of burrowing Procellariiformes have been described, suggesting that nest site quality may affect breeding success (Warham, 1990, 1996). More than 400 pairs breed on the Island of Benidorm, most of them in two high-density colonies located inside small caves (Mínguez, 1994) which are subjected to high disturbance risk.

Breeding success of the Benidorm Island population may be affected by nest-site related factors and nest predation by yellow-legged gulls *Larus cachinnans* (Mínguez, 1994). Storm petrels are believed to avoid predation by being strictly nocturnal (Warham, 1990), a bright moon tending to reduce night-time activity over land and facilitating predation by gulls (Bretagnolle, 1990; Watanuki, 1986). On Benidorm Island, the largest colony may have the additional problem of strong light coming from Benidorm city, only two miles away from the island.

To counteract the likely decrease in productivity we followed the experiment by Bolton (1996), who successfully installed artificial PVC nest-boxes for this species. The aims of this management measure were (a) to increase availability of suitable nest sites, (b) to protect vulnerable nests from predation by yellow-legged gulls, and (c) to promote the increase of breeding pairs in an area without light pollution from Benidorm city.

This study presents data on occupancy levels and nesting success in nest-boxes installed in two storm-petrel colonies on Benidorm Island. If there is a shortage of nesting sites, we would expect a high level of occupation of nest-boxes. Also, if nest-box characteristics are adequate regarding protection of eggs and chicks from inter- and intraspecific destruction and predation, their presence is expected to result in an increased breeding success.

METHODS

Eighty-six artificial nest-boxes were installed inside two caves occupied by European storm-petrels on the island of Benidorm, western Mediterranean (38°30'N, 0°08'W) in November 1996.

The design of the artificial nest-boxes is straightforward, inexpensive and endurable (after Bolton 1996). It consists of a rectangular nesting chamber (25 x 12 cm) accessed via a short tunnel (~10 cm). Nest-boxes were manufactured from plastic containers. The PVC box was perforated to allow drainage, and transpiration and body heat dissipation from its potential occupants. The entrance tunnel prevents predation of adults, eggs or chicks by gulls. Sand from the surroundings of the colonies was inserted into the boxes to provide an adequate substratum for nest construction.

Forty-five nest-boxes were installed in a cave which contains the largest colony on the island (Colony I), located just in front of Benidorm city and hence perceptibly illuminated at night. Forty-one boxes were placed inside a smaller cave, on a dark side of the island (Colony II) with no light pollution from the city. Seventy-nine of the 86 nest-boxes (ca. 92%) were installed on places without previous presence of nests, to increase availability of nest sites ("new" nest-boxes hereafter). Seven nest-boxes ("old" boxes) were placed on top of former natural nests which were known to be highly exposed to perturbation by gull chicks (own data). Three nest-boxes were lost in Colony II, presumably owing to winter storm waves.

About 200 natural nests were monitored from 1993. Occupancy rates and nesting success of nest-boxes and a variable number of natural nests were determined during the breeding seasons of 1997 to 2001. We considered a nest as occupied if there was an adult bird incubating in at least one of the visits. We considered that chicks had fledged if they were at least 35 days old when observed last time. Nesting success is the proportion of chicks fledged in relation to the number of eggs laid.

Data are expressed as means $\pm$ standard deviations. All tests are two-tailed.

RESULTS

One year after installation 6% (5/86) of the "old" nest-boxes were occupied. No "new" nest-box was occupied that year, although we recorded adults visiting them. In 1998 both types of boxes were occupied by breeding pairs (7/86; 8%). Occupancy rate increased gradually in 1999, 2000 and 2001, with 18/84 (21%), 22/84 (26%) and 24/83 (29%) boxes occupied respectively. Occupancy rate increased significantly throughout the five years of study ($\chi^2 = 24.56$, $P < 0.0001$).

TABLE 1. – Annual occupancy rates (occupied nests/total and percentage) in Colonies I and II in relation to nest-box type during the five years of study. “New” are nest boxes placed on sites without old nests, and “old” refer to boxes placed on top of former nests.

YEAR	Colony I		Colony II	
	New type	Old type	New type	Old type
1997	0/43 (0 %)	1/2 (50%)	0/36 (0%)	4/5 (80%)
1998	2/43 (5 %)	1/2 (50%)	3/36 (8 %)	1/5 (20%)
1999	3/43 (7 %)	2/2 (100%)	9/35 (26 %)	3/4 (75%)
2000	3/43 (7 %)	2/2 (100%)	12/35 (34%)	4/4 (100%)
2001	2/43 (5 %)	1/2 (50%)	17/34 (50 %)	4/4 (100%)

Occupancy rates in new type boxes were higher in Colony II than in Colony I during the last three years of study (Fisher Exact Tests; year 1999, $P = 0.029$; year 2000, $P = 0.003$; year 2001, $P < 0.0001$, Table 1), probably due to the smaller number of appropriate nest sites in this cave. Old type nest-boxes had higher occupancy rates than new type boxes during the five years of study (Fisher Exact Tests; year 1997, $P < 0.0001$; year 1998, $P = 0.098$; year 1999, $P = 0.001$; year 2000, $P < 0.0001$; year 2001, $P = 0.007$, Table 1)

Table 2 shows annual nesting success in nest-boxes and natural nests. A GLM model including type of nest (natural, new and old), colony and year as explanatory variables revealed that type of nest was the variable with the greatest effect ($F_{875,2} = 2.71$, $P = 0.067$).

Our results suggest that breeding success in nest-boxes tended to be higher than breeding success in natural crevices. Since natural nests had been monitored since 1993, presumably most of them were occupied by more experienced pairs than those occupying nest-boxes installed in 1996. In order to remove this effect we analysed data using mean breeding success of nests with at least three breeding attempts recorded. Pairs breeding in nest-boxes had higher nesting success (0.77 ± 0.22 , $n = 13$) than those breeding in natural nests (0.50 ± 0.29 , $n = 66$; Mann-Whitney U Test; $U = 208.0$, $n = 79$, $P = 0.003$, Fig. 1).

TABLE 2. – Annual nesting success in natural nests and nest-boxes (i.e. proportion of chicks fledged over eggs laid; mean $\pm$ SD, n).

Year	Natural nests	Nest-boxes
1997	0.49 $\pm$ 0.50 (175)	0.40 $\pm$ 0.55 (5)
1998	0.36 $\pm$ 0.48 (165)	0.67 $\pm$ 0.52 (6)
1999	0.49 $\pm$ 0.50 (183)	0.75 $\pm$ 0.45 (16)
2000	0.42 $\pm$ 0.50 (183)	0.62 $\pm$ 0.50 (21)
2001	0.48 $\pm$ 0.50 (97)	0.63 $\pm$ 0.49 (24)

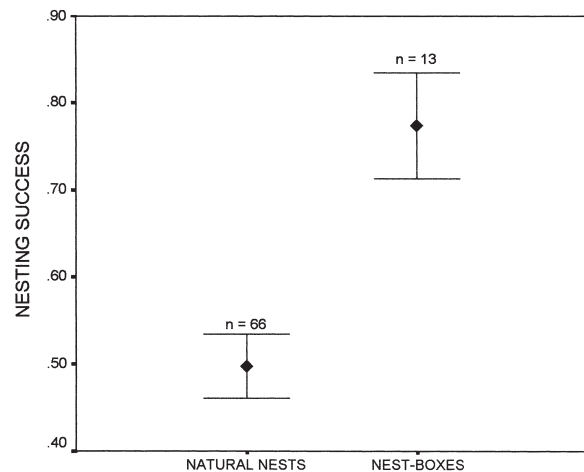


FIG. 1. – Mean breeding success ($\pm$ SE) in natural nests and nest-boxes during the five years of study. We considered the average breeding success of pairs with at least three recorded breeding attempts.

DISCUSSION

The results show that our plastic nest-boxes were attractive for European storm-petrels. Laying occurred in the first year after their installation on top of natural nests, and in the second year in nest-boxes placed on sites without nests. Five years after installation, 29% of nest-boxes were occupied by breeding storm-petrels. Thus, occupation rates seem to be high and increase relatively rapidly, considering the life-history traits of petrels. Nest chambers located on sites known to have been occupied by storm petrels during the previous year on the island of Mousa (Shetlands) showed occupancy rates of 35% and breeding success did not differ from that of birds breeding at natural sites (Bolton, 1996). In Benidorm, old type boxes showed higher occupancy rates than new type boxes almost every year. Furthermore, nesting success of pairs breeding inside boxes was higher than that of pairs at natural sites. Among Procellariiformes occupancy rates of artificial nests vary both intra- and interspecifically (e.g. 50% for *Calonectris diomedea*; Ramos *et al.*, 1997; and 23% for *Puffinus puffinus*; Brooke, 1990).

This study shows that occupancy rates can vary between colonies, even between those located on the same small island, probably in relation to the availability of natural nests. Factors influencing nest-site selection in the European storm-petrel are not well known. Nest-boxes were installed in two high-density breeding colonies where non-breeding birds are likely to be attracted by conspecifics. We did not detect any increase in the number of natural holes occupied by breeding storm-petrels on Benidorm

Island during the period 1997-2001, suggesting that most of the new nest-boxes were occupied by prospecting storm-petrels. Small petrels usually occupy small nest cavities, where they may achieve a high degree of protection (Ramos *et al.*, 1997). Selection of nest-boxes would be related to (a) diameter and length of the entrance tunnel, which protects the nesting chamber against large predators such as gulls and (b) size of the nesting chamber, which can only host one breeding pair.

Factors that increase breeding success inside artificial nest-boxes are unknown. Among Procellariiformes many broken eggs are found in very exposed nest cavities which offer little protection in poor weather (Warham, 1990, 1996) or against predators such as gulls (Zino, 1971). Some Procellariiformes species readily use artificial burrows and those that do have higher than average nesting success (Byrd *et al.*, 1983). Thermal conditions inside boxes could also be important (Bolton, 1994). Also, interference competition for adequate nest cavities can influence hatching success in *Oceanodroma castro* (Ramos *et al.*, 1997). The fact that nesting chamber size allows occupation by only one breeding pair, could decrease intraspecific interferences (egg breakage due to trampling by the adults, adult-chick attacks, infanticides, etc.; Warham, 1990.).

These nesting boxes were inexpensive and very durable, so the use of artificial nest-boxes could have a wide variety of management applications such as increasing availability of suitable nest sites, protecting vulnerable nests from predation and possibly promoting population increases in colonies without disturbance or light pollution. Attraction of prospecting birds to safe sites where nest-boxes are installed shows great potential for managing threatened seabirds. This is especially true in the Mediterranean, where most storm-petrel colonies are located on small islets with low availability of suitable cavities for breeding.

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