

Establishing repeatable study plots on Sa Dragonera, Mallorca to assess population trends of the local breeding Balearic Shearwaters *Puffinus mauretanicus*

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Abstract

The Balearic Shearwater *Puffinus mauretanicus* is a Critically Endangered species endemic to the Balearic Islands, subject to a severe decline that could lead to the extinction of the species within three generations (Oro *et al.* 2004). Predation by introduced mammals is considered the main threat facing the species at its breeding grounds, and therefore conservation action is required along with subsequent monitoring in a species where such information is lacking. In order to assess the long-term impact of a rodent eradication project on the breeding success of the species on Sa Dragonera island, a series of study plots were established in April 2013. A survey was carried out to establish the minimum number of known Apparently Occupied Sites (AOS) within each plot. All potential nest sites within each plot were sampled for the presence of a bird(s) using a combination of methods: (i) tape playback, (ii) physical sighting (by eye or with an endoscope) and (iii) obvious signs of occupation. 33 AOS in 12 study plots were identified. This project was not a whole island estimate; rather it led to the establishment of a series of repeatable study plots, providing reference estimates of breeding pairs in defined areas on the island to enable monitoring of future changes in the population size following predator removal.

Introduction

The Balearic Shearwater *Puffinus mauretanicus* is an endemic nesting seabird to the Balearic Islands, listed as Critically Endangered on the IUCN red list due to a severe population decline that could lead to its extinction in less than three generations (Oro *et al.* 2004). On land, its main threat is predation by introduced mammals, such as rodents (Rodentia) and feral cats *Felis catus* (Arcos 2011). For

this reason, birds only come ashore at night to minimise predation risk, and breed in karstic caves and crevices on islands and coastal cliffs with difficult access. Such factors make the Balearic Shearwater a difficult species to census, as is the case with other procellariids. The most recent global breeding population estimate is 3,193 pairs, all of which are restricted to the Balearic Islands, with an effective breeding range of less than 100 km² (Arcos 2011). The only previous estimate of total population size on Sa Dragonera was 400 pairs in 2009, reported as being of 'low confidence' and based mainly on counts of rafting birds at sea (Ruiz & Martí 2004). Setting monitoring schemes to properly assess population size and trends is key to understanding the population dynamics of the species.

Sa Dragonera (39°35'N 02°19'E) is an uninhabited island in the Balearic Islands, Spain, located 1 km off the west coast of Mallorca. In 1995, along with the smaller neighbouring island of Pantaleu, it was declared a Natural Park. It is 356 ha in size measuring approximately 1 km from north to south, and 4 km from east to west. The main rock outcrops are Jurassic and Triassic limestone, forming a Karst topography penetrated by a large number of caves and crevices. Apart from a single road that runs NE to SW, and services the lighthouses located at either end of the island, the terrain is steep and rocky, rising sharply from sea level to the highest peak at over 350 m, dropping vertically along the northwest coast. The steep ridges are dominated by scrub, which becomes impenetrable in places, and consists mainly of two communities of Mediterranean Scrubland: 1) *Cneoro-Ceratonion* with *Olea europaea* and *Phillyrea angustifolia* and 2) *Rosmarino-Ericion* with areas of dense Aleppo Pine *Pinus halepensis* (de Bolòs 1996; Ordinas & Reynés 1996).

In early 2011, the Balearic Islands government undertook a rodent eradication programme on the island, removing Black Rats *Rattus rattus* and House Mice *Mus musculus* (Mayol *et al.* 2012). The project appears to have been successful, with camera traps and tracking tunnels showing no signs of either species in the intervening years. In addition to this removal campaign, feral goats were eradicated in the early 1980s. The only terrestrial mammal that remains today is the European Rabbit *Oryctolagus cuniculus*.

The aim of this work was to establish a series of repeatable population study plots to assess the long term impact of the 2011 rodent eradication project on the breeding population of Balearic Shearwaters on Sa Dragonera. This provided both a partial census and a base year index for future surveys of these areas.

Methods

We used a combination of methods to ascertain if a site was apparently occupied (an AOS): (i) tape play back; (ii) physical sighting of an incubating bird or an egg; (iii) obvious signs of site occupation. Due to time constraints only a single visit was made to each site. All visits were diurnal and took place from 5–14 April 2013.

Tape playback: It has been demonstrated previously that the vocal response of the Balearic Shearwater to conspecific calls is sex specific (Curé *et al.* 2010). This has also been demonstrated in other members of the *Puffinus* genus, e.g. Manx Shearwater *Puffinus puffinus* (Brooke 1990; Perrins *et al.* 2012). A tape recording was produced consisting of 15 seconds of male Balearic Shearwater call, followed by 15 seconds of female call. Both recordings were made by one of the authors at breeding sites on the island of Malgrats, Mallorca on 26 March 2009, using a Wildlife Acoustics Song Meter Version 1.

The tape was played at 'normal volume' at the entrance to all suitable sites within the study areas. The male call was played first, followed by a 10 second gap, and then the female call. A record was made if either a male or female bird responded. Male calls were played first, as it was assumed that Balearic Shearwaters follow the pattern of other similar *Puffinus* species, where sex-specific responses are prevalent, i.e. males are known to respond to male calls on most occasions, and females are known to respond to female calls, but at a much lower rate, and never to male calls (Smith *et al.* 2001).

We failed to locate a large enough sample of AOS to carry out any form of site-specific response rate work for the tape playback element of the study. Tape playback was purely used as a means to detect actual occupied sites, and the results represent a minimum number for each study plot. Repeated visits would provide more robust estimates as the chances of a response increases and should be considered for future surveys if time permits.

Physical sighting: If no response was forthcoming from tape playback, the site was checked for the physical presence of an incubating bird on an egg. In some cases the bird was nesting so close to the entrance, or in a deep crack, that it could be seen by eye with the aid of a red torch light. In most cases, an endoscope was needed to look further into the potential breeding site. If this method yielded the sighting of an obviously incubating bird, or an egg, then the site was marked as an apparent breeding site. In most cases the lack of response to the tape led on to the use of the endoscope where possible but in some cases the bird was clearly visible before the tape was played, in which case the tape was not played as the AOS had been confirmed visually.

Obvious signs of occupation: If no response to tape playback was received and no physical sighting was possible (in some cases the breeding chamber was too deep for the endoscope), then the site was only marked as an AOS if fresh guano was present outside the entrance. These sites usually contained a strong characteristic shearwater smell, but this observation alone, in the absence of guano, did not result in the site being classed as occupied. Occasional non-breeders occupying nest sites by day would produce a smell, whereas the presence of guano at the entrance implied a more regular use of the site. Although not proven for Balearic Shearwaters during this study, it was assumed that they follow behaviours similar to Manx Shearwaters, whereby few non-breeders occupy burrows by day and even

fewer will respond to tape playback (Smith *et al.* 2001). Scratch marks on rocks immediately adjacent to, or above, the entrance were also recorded. Scratch marks alone were not used as a sign of occupation in the absence of fresh guano.

Selection of study plots: The dense scrub covering many areas of Sa Dragonera was not thought to be suitable habitat for breeding shearwaters. In general this proved to be the case; however, we did find some scrub areas that contained occupied breeding sites. As a result, we set up plots both in areas around the coast of the island, and along the high rocky ridges that border deep scrub-filled valleys. Most of these areas were open and consisted of large boulders or 'boulder-cliffs' (i.e. very large rocks with birds nesting at the base, or in deep cracks within). Some areas contained small cave systems that housed multiple breeding pairs. No plots were selected at cliff sites due to difficulty of access but it is thought that the precipitous northern cliffs could contain breeding shearwaters. When rodents were present on the island some of these areas were likely to have been free from predation pressure due to their precipitous location but other sections of cliff could have allowed predator access. Any full surveys in future should try and include these areas if possible. The boundaries of each study plot were carefully marked using a GPS (Table 1) and plotted on a map (Figure 1).

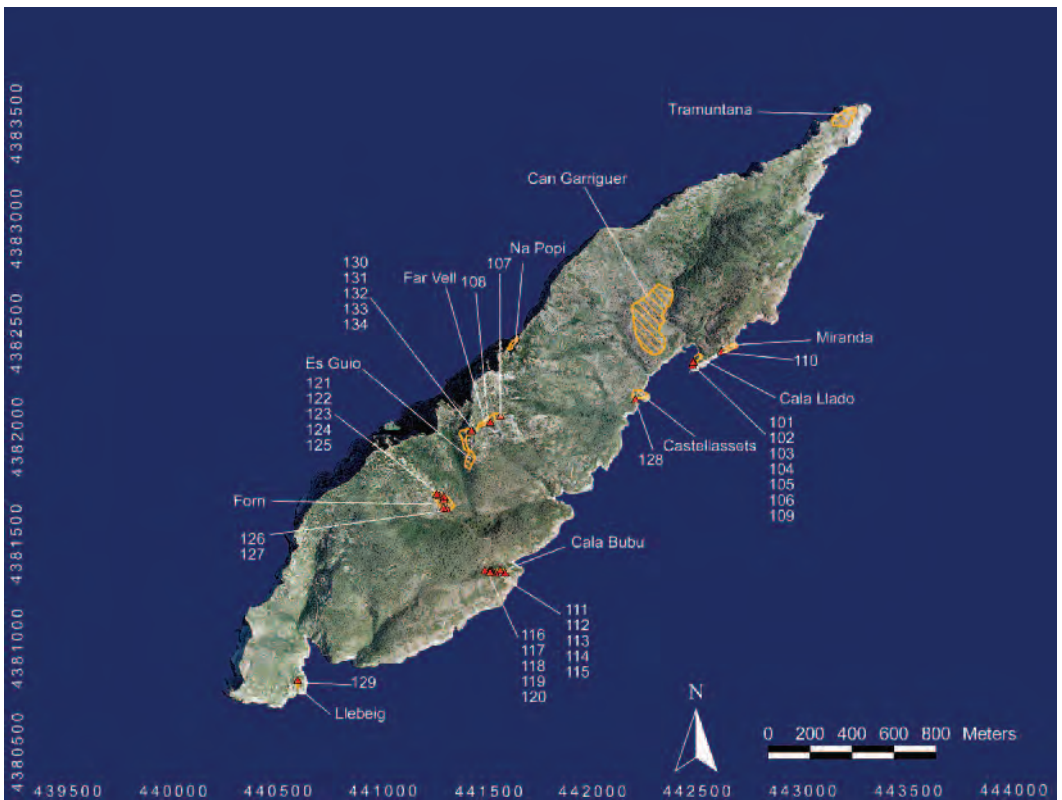


Figure 1. Locations of Balearic Shearwater *Puffinus mauretanicus* study plots and nest sites on Sa Dragonera.

Table 1. Detailed summary of Balearic Shearwater *Puffinus mauretanicus* Apparently Occupied Sites (AOS) recorded during single visit plot surveys on Sa Dragonera, Mallorca in April 2013.

Study plot no. and name	Habitat Type	Nest Marker ID	Date	No. of birds at nest site	Northing	Easting	Site Determiner		
1. Cala Liado	Coastal boulders	101	5/4	1	442480	4382361	Response to male call		
		102	5/4	1	442481	4382346	Visual sighting of bird and egg but no response to tape		
		103	5/4	1	442484	4382360	Response to male call		
		104	5/4	1	442484	4382364	Response to male call		
		105	5/4	1	442477	4382370	Visual sighting of bird		
		106	5/4	1	442484	4382361	Bird visible with endoscope		
		109	7/4	1	442479	4382378	Bird and egg visible with endoscope		
		2. Far Vell	High rock ridge	107	6/4	1	441565	4382105	Fresh signs of occupation
				108	6/4	1	441517	4382074	Bird visible with endoscope
3. Miranda	Coastal boulders	110	7/4	1	442617	4382412	Fresh signs of occupation		
4. Cala en Bubu	Coastal ridge	111	7/4	1	441588	4381356	Fresh signs of occupation		
		112	7/4	1	441565	4381369	Fresh signs of occupation		
		114	7/4	1	441525	4381366	Visual sighting of bird		
		115	7/4	1	4415269	4381362	Visual sighting of bird		
		116	7/4	0	441516	4381369	Potential site for future. Not occupied in 2013		
		117	7/4	0	441517	4381364	Contained a breeding Scopoli's Shearwater <i>Calonectris diomedea</i>		
		118	7/4	0	441490	4381368	Potential site for future. Not occupied in 2013		
		119	7/4	1	441515	4381363	Visual sighting of bird and egg		
5. Cala Bubu Cave	Coastal cave	120	7/4	0	441515	4381362	Potential site for future. Not occupied in 2013		
		113	7/4	3	441542	4381356	3 x incubating adults visible in small cave system		
		6. Forn de Cal	High rock ridge with 'boulder cliffs'	121	9/4	1	441296	4381719	Response to male call
				122	9/4	1	441296	4381720	Response to male call
				123	9/4	1	441295	4381706	Fresh signs of occupation and bird heard moving around
				124	9/4	1	441274	4381725	Visual sighting of bird
				125	9/4	1	441261	4381731	Response to male call
126	9/4			1	441294	4381666	Visual sighting of bird		
127	9/4	1	441309	4381661	Fresh signs of occupation				

7. Castellassets	Coastal boulders	128	11/4	1	442208	4382184	Fresh signs of occupation	
8. Llebeig	Coastal cave and cliff face	129	11/4	3	440599	4380843	3 x responses to male tape in small cave complex. Possibly more birds inside but access not possible.	
		129a	11/4	1	No data	No data	1 x obvious sign of occupation on sheer cliff on back face of cave (not marked as inaccessible without ropes)	
		130	14/4	1	441426	4382035	Response to male call	
9. Es Guio	High rock ridge	131	14/4	1	441426	4382035	Response to male call	
		132	14/4	1	441426	4382035	Response to male call (130–132 in same boulder complex)	
		133	14/4	0	441423	4382033	Potential site for future. Not occupied in 2013	
		134	14/4	0	441429	4382036.	Potential site for future. Not occupied in 2013	
10. Tramuntana	Coastal scree	n/a	6/4	0	n/a	n/a	n/a	
11. Sa Popi	Cliff face	n/a	13/4	0	n/a	n/a	n/a	n/a
12. Can Garriguer	Rock ridge	n/a	13/4	0	n/a	n/a	n/a	n/a
Total AOS = 33								

Study plots should be simple to relocate in future years, allowing repeat surveys to be carried out. They provide coverage across the whole island in a variety of habitat types, from coastal boulders to high ridges. The plots varied in size dependent on the habitat type, but each was surveyed within a working day using two to three people. A GPS location (using UTM geographic coordinate system. Zone 31S. DATUM EUROPEAN 1950) was recorded for all AOS, and each site was physically marked using numbered metal tags that were either nailed into cracks in the rock, suspended with wire, or nailed into the ground on pegs.

Results

A minimum of 33 AOS were identified in the 12 study plots, at an altitudinal range of 5–246 m above sea level. In three of the 12 study plots (numbers 10–12), no birds were found. Of the 33 confirmed AOS, 12 were identified by male birds responding to tape play back of the male call (where bird not visible, see Methods), 13 were from visual sightings of

an incubating bird or an egg, and eight were from obvious and regular use of the site (i.e. guano, smell and/or scratch marks in or around the entrance).

No females responded to the female call during the survey. To test that the female call worked, a site that had held a responding male bird (to the male call) was checked for incubation change-over several days later. In this instance, playing the female call yielded a female response. A true test would have been to play the female call before the male call on occasion, as it is possible that playing the male call first might have discouraged females from calling back when the female call was subsequently played. An option for future surveys would be to play the calls of a duetting pair so that both sexes are heard simultaneously. This method appears to work for Manx Shearwaters, and produces a higher response rate than the male call alone (Brown *et al.* 2011).

Discussion

While this work does not provide a population estimate of breeding pairs of Balearic Shearwaters on Sa Dragonera, it has led to the establishment of a series of easily repeatable study plots that can be used to track patterns of the species' potential expansion at this site. It is possible that this method could be extrapolated to other colonies and improve our knowledge of the breeding population of this critically endangered species.



Figure 2. Tim Guilford and Greg Morgan outside a cave containing Balearic Shearwater *Puffinus mauretanicus* nest sites, Sa Dragonera, April 2013. © Russell Wynn.



Figure 3. Study Plot 1, containing seven Balearic Shearwater *Puffinus mauretanicus* nest sites, Sa Dragonera, April 2013. © Greg Morgan.

The recent removal of mammalian predators will undoubtedly enhance the chances of future population expansion at the site but the lack of any accurate population estimate on Sa Dragonera prior to the eradication project will limit the extent to which comparisons on this basis can be made. The results of the 2013 survey will act as a baseline dataset for future surveys.

On Lundy Island and Ramsey Island in the UK, the eradication of Brown Rats *Rattus norvegicus* has resulted in a significant increase in the numbers of breeding Manx Shearwaters at these locations over the past 10 years (Brown *et al.* 2011; Morgan 2012). Notable increases were seen in the first few years after eradication; however, both islands are close to the mega populations of Skomer and Skokholm Islands and benefit from non-breeder immigration from these colonies. With comparatively fewer Balearic Shearwaters in the Mediterranean region, we hypothesise that any increase in the Sa Dragonera population is likely to be slower. However, recent studies indicate a discrepancy between actual known breeding pairs and total numbers of birds in the region. At sea estimates have accounted for around 25,000 individuals (Arcos *et al.* 2012) compared with the 3,193 breeding pairs estimated (Arcos 2011).

There is no established methodology for monitoring breeding sites of Balearic Shearwaters. The nature of their nesting habitat, mostly caves and crevices that could harbour many individuals using one entrance, complicates the matter. On Sa Dragonera, given that numbers are likely to be small, we attempted to locate all breeding sites within each study plot, as described above. The 33 identified nest sites are a minimum estimate for these plots. There are likely to have been

more pairs present in some areas, which didn't respond to playback and could not be detected via other methods. However, by replicating this method in future years a relative change in each plot can be calculated and the ongoing response to predator removal can be monitored.

Monitoring any procellariid is difficult, and in the case of the Balearic Shearwater is further complicated given its breeding habitat and small population size. While the establishment of the survey methodology outlined in this study provides a step towards an improved monitoring framework, further work is needed to produce a series of robust baseline counts for this species at other sites across the region in order to assess temporal trends on a wider scale.

Future work on Sa Dragonera: Following this initial project, the following recommendations are made for future work:

- Repeat these study plot surveys every 2–3 years, in order to monitor relative change in the number of breeding pairs in each plot.
- Permanently mark the initial 33 sites, and all other sites found in subsequent years.
- Calculate a response rate for this species for use in future tape play back surveys. Ideally this would require a minimum of 40–50 accessible sites. This is likely to take some years to establish on Sa Dragonera. The installation of artificial nest boxes in Cala Llado (the harbour plot) would make this goal easier, and also provide a population for tracking and productivity work.
- Attempt a full island census of Sa Dragonera using methods described here on a wider scale. This would involve a greater time investment, increased manpower and the use of climbers to abseil to some of the potential nesting sites on the west side of the island. A response rate would need to be calculated prior to this work.
- Given the expense and effort that went into eradicating rodents in the first place, ensure adequate biosecurity measures are in place to prevent accidental reintroduction. Ink traps and trail cameras are already in use on the island but are only monitored when staff from a local NGO are present. National Park staff are present most days and should be encouraged to contribute to this monitoring on a weekly basis. Day visitors should be asked to check their bags for pests on the trip over to the island. Signs to this effect should be displayed both at the mainland departure point and at the arrival point on Sa Dragonera, to ensure that tourists, and visitors landing from private vessels, are aware of biosecurity risks.
- Ensure an adequate rodent destruction kit is present on the island to enable a swift response in the event of a rat sighting (Bell *et al.* 2000).

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