

Population size and breeding ecology of the Mediterranean Storm-petrel *Hydrobates pelagicus melitensis* on Illa de l'Aire, Menorca

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The European Storm-petrel is a small seabird widely distributed throughout Europe. The first recorded description of this species from Menorca is from 1957 and breeding was confirmed in 1991 on Illa de l'Aire off the south-east coast of the island. Very little is known about the size of this breeding population and its breeding parameters on Menorca, which are based on casual observations. The main purpose of the present study was 1) to identify other potential new breeding storm-petrel colonies on Menorca; 2) to estimate its breeding population size on Illa de l'Aire; and 3) to obtain preliminary information on its breeding biology on this island. In 2019–2022 considerable efforts were devoted to finding other breeding colonies on Menorca but none was found. Four breeding areas were identified on this island, which contain a minimum of 33 active nests in 2019, the year with more breeding pairs. However, most of the adequate sites for breeding on this island are totally inaccessible and so the total storm-petrel population there is probably much higher. We captured 185 birds and ringed 70. Even though gathering data for this species at this site is difficult, we advocate the establishment of an annual monitoring program in the island as a way of obtaining a good estimate of the conservation status and the population trend of the European Storm-petrel on Menorca.

Key words: European Storm-petrel, population size, breeding ecology, monitoring program, Illa de l'Aire, Balearics.

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Received: 16/01/22; Accepted: 19/10/22 / Edited by M.Genovart

The European Storm-petrel *Hydrobates pelagicus*, a small seabird widely distributed throughout Europe, mainly breeds on offshore islands, with its greatest numbers in the Faroe Islands, United Kingdom, Ireland and Iceland. Its wingspan is twice its body length giving it long narrow-winged appearance. It also has characteristic webbed feet and a bill and nostrils adapted to excrete excess salt. The Atlantic subspecies *pelagicus* is smaller than the Mediterranean subspecies *melitensis*, and is about 14 cm in length and weighs around 30 g (del Hoyo *et al.* 1992, Sanz-Aguilar *et al.* 2019a). Egg-laying usually starts in the second half of April and lasts until July, with a peak in early May. Birds lay a single egg that is incubated for 40 days by both sexes; the

chick remains in the nest for 63–70 days before fledging (Sanz-Aguilar *et al.* 2019b).

Storm-petrels spend most of their lives at sea (del Hoyo *et al.* 1992, Sanz-Aguilar *et al.* 2019a) and despite their fragile appearance are well adapted to an oceanic lifestyle. Most common names reflect this ability: *marimeret* or *bruixa* in Menorca, *ocell de tempesta* in Catalonia, Storm-petrel in English, *océanite tempête* in French and *uccello delle tempeste* in Italian. It breeds in numerous colonies along the coasts, islands and islets of Europe and is considered Endangered by the *Red List of Birds of Spain* and 'of special interest' in *National Catalogue of Threatened Species* (Mínguez 2004, Sanz-Aguilar *et al.* 2019a). Due to its nocturnal habits and the fact

it breeds in isolated and sometimes inaccessible areas, population sizes and trends are difficult to estimate. The most recent global population estimates suggest there are 430,000–510,000 breeding pairs, of which 4,278–6,528 are in Spain (Sanz-Aguilar *et al.* 2019a). The overall Mediterranean population is in decline and does not exceed 16,000 breeding pairs (BirdLife International 2004). However, in some well-studied areas such as Benidorm Island the storm-petrel population seems to be stable (Mínguez *et al.* 2007, Sanz-Aguilar *et al.* 2019a).

In the eastern Iberian Peninsula, this storm-petrel breeds on islets off the coasts of Almería (Isla de Terreros), Murcia (Grosa, Hormigas, Las Palomas) and Alicante (Benidorm, Mitjana, Tabarca, Columbrets), while in the Balearic Islands there are at least 27 known colonies on islets off Ibiza, Formentera, Mallorca and Cabrera (Sanz-Aguilar *et al.* 2019b). Its overall population size is poorly known and, for instance, the largest colony on the island of Espartar (Ibiza) is estimated to contain 500–2,500 pairs; nevertheless, most colonies hold less than 50 breeding pairs (Sanz-Aguilar *et al.* 2019b).

The first recorded description of this species from Menorca is from 1957 (Moll 1957) but with no mention of breeding. Today, however, it is a well-known to those working at sea around Menorca (Catchot 1991), although it is largely overlooked by most ornithologists due to its pelagic habits. In 1991, when studying migratory passerines on the Illa de l'Aire, some Mediterranean Storm-petrels were accidentally captured in mist-nets and later that same year breeding was confirmed on this islet (Catchot 1991). The first study of this breeding colony estimated a breeding population of 1,351 individuals (Santana 2008). Some authors also mention the island of Bleda as a possible breeding ground for the species on Menorca (Aguilar 1991), although no specimens have yet been captured there. This islet has a large number of rats and breeding has not been proved there. Efforts have been made to find other breeding colonies on Menorca and on nearby islets but it has only ever been confirmed on Illa de l'Aire (Catchot 1991, Santana 2008).

The main purpose of the present study was thus 1) to identify other potential new breeding colonies of Mediterranean Storm-petrel on Menorca; 2) estimate its breeding population

size on Illa de l'Aire; and 3) obtain preliminary information regarding the distribution and accessibility of nests as a means of evaluating the feasibility of setting up a monitoring program to estimate fertility and adult survival rate and so to identify any trends operating in its population.

Material and methods

The Illa de l'Aire (~35 ha) is located off the south-east coast of Menorca and is separated from the main island by a channel of just over 1 km in width. It is Miocene in origin and has a maximum height of 15 m a.s.l. In some areas there are crevices and large rocks that are ideal sites for seabirds to breed in. There are no rats or mice and the only mammal present on the island is the rabbit *Oryctolagus cuniculus*. These characteristics make this island a key breeding ground for seabirds and breeding has been documented for the European Shag *Phalacrocorax aristotelis* (about 20 pairs), Yellow-legged gull *Larus michahellis* (235 pairs), Audouin's gull *Ichthyaetus audouinii* (80–150 pairs), Scopoli's shearwater *Calonectris diomedea* (80–100 pairs) and Yelkouan Shearwater *Puffinus yelkouan* (3–5 pairs) (pers. observ. and Menorca Reserve Biosphere Agency documents). In addition, Illa de l'Aire is the only known breeding colony on or around Menorca of the Mediterranean Storm-petrel (Catchot 1991, Santana 2008). This islet lies about 140 km away from the next nearest colony (islets around Cabrera) and far from its main known feeding areas (Bécares *et al.* 2011, Rotger *et al.* 2021). Very little is known about the breeding dynamics of this species on Menorca and most is based on casual observations: a disoriented young bird found in the city of Maó on 1 August 2017, birds observed on nests on 27 March 2018, and a chick heard and observed on 15 June 2018.

Land surveys were carried out in 2019, 2020, 2021 and 2022 on the only accessible parts of the island. Before this study, only two breeding areas (Nord and Bufador, see below), 500 m from each other, had been identified on the island. Its southern coast seems to be the best suited for breeding. Several nocturnal transects were performed with nocturnal playback and listening stations, preferably on nights with no moon and

little wind. After playing the recording of the call (30 seconds), 30 seconds were allowed to pass, or more if there was a response. Based on the methodology used by Mínguez *et al.* (2007), these transects were performed three times every year, once in April, May and June.

We considered each response as proof of breeding. Based on the survey in the first year, we defined a reference study area of one hectare that was then monitored annually to obtain estimates of the number of birds and nests. In 2019, we also carried out prospections on other Menorcan islets including Porros, Illes d'Addaia, Àguiles and Binicodrell and visited a number of caves along the coast and other islets, using mist-nets and playback at night. Some caves along the northern inlets on the mainland were not accessible from the ground and were checked from the sea. Illa de Colom was not visited but the possibility of a storm-petrel breeding colony there was ruled out due to the high density of rats on this islet.

When we found a burrow, we checked for occupancy and tried to determine whether it contained a single adult, an adult with an egg, or an adult with a chick. If it was occupied by an adult or a chick, we tried to capture them. During the winter of 2020, we also installed seven nest boxes in a cave where birds were already breeding in an attempt to increase the availability of breeding sites and/or to facilitate the monitoring of breeding in the future. We recorded the number of nests found and the number of chicks observed or heard in the colonies but did not attempt to estimate the breeding success as the fate of individual nests was not monitored.

Every year, we captured birds at nests using mist-nets but without playing tapes. During the 2019 breeding season we captured birds in 11 different sessions but in 2020, 2021 and 2022 we only captured birds during two consecutive sessions each year. Mist-nets were used in the two largest breeding areas, La Cova (only in



Figure 1. Small GPS device fitted on the central rectrices tail feathers.
Petit GPS col·locat a les plomes rectrius centrals de la cua.

Table 1. Number of nests and chicks registered on Illa de l'Aire during the study period.
Nombre de nius i pollets registrats a l'illa de l'Aire durant el període d'estudi.

	Nº of nests found				Nº of chicks recorded			
	2019	2020	2021	2022	2019	2020	2021	2022
<i>La Cova</i>	9	8	7	8	4	3	1	3
<i>Niu de Puffinus</i>	5	5	5	2	3	3	0	2
<i>Far</i>	2	1	0	0	1	0	0	0
<i>Bufador</i>	17	11	8	10	6	2	3	2
<i>Nord</i>	0	0	0	0	0	0	0	0
Total	33	25	20	20	14	8	4	7

2019) and Bufador (see below). When a bird was caught, it was ringed but measurements were kept to a minimum to reduce disturbance to potential breeding birds. In 2019, we checked for the presence or absence of brood patches to determine breeding status, measured wing length and weight, and checked for parasites. A concerted effort was also made to ring the chicks.

The size of the colony on Illa de l'Aire was estimated using two types of data: 1) nests observed when searching and listening; 2) mist-net capture-recapture data. To estimate population size with capture-recapture data we applied the Lincoln-Petersen estimator to captures made on two consecutive days (Tellería 1984). For 2019, as we had data from several sessions, we choose the two consecutive sessions with most captures. We estimated the population size of the two main sub-colonies, Sa Cova and Bufador, in 2019 but only of Bufador in 2020, 2021 and 2022.

To obtain information on foraging grounds and individual movements of storm-petrels from this isolated colony, in 2021 we attached GPS devices to six breeding birds from the island. These tiny water-resistant Pathtrack GPS weigh only

0.8 g and allowed us to make a thorough study of petrels' foraging trips. The GPS were fitted to the four central rectrices during incubation (Fig. 1). We placed four GPS on four birds but removed them during the breeding season when birds returned to their nest sites. We also used two of these GPS to mark a further two individuals. GPS placements were performed with help of experts in this type of manipulation (Ana Sanz and Andreu Rotger from IMEDEA).

Results

During the land and listening surveys, we visited the two previously known possible breeding areas (Nord and Bufador) and identified three new breeding areas (Niu de Puffinus, Far and La Cova). During the study period, we found nine nests (seven in burrows and two by listening) in La Cova, five (three in burrows and two by listening) in Niu de Puffinus, two (one in a burrow and one by listening) in Far, 17 (two burrows and 15 by listening) in Bufador, but none in Nord, where a nest with a chick had been recorded in 2018. No evidence of the presence of Mediterranean Storm-petrels anywhere but on Illa de l'Aire was obtained. None of the seven nest boxes placed in a cave on Illa de l'Aire were occupied.

From 2019 to 2022, the number of nests recorded decreased from 33 to 20. (Table 1). In 2019 we registered (observed or by listening) a total of 33 chicks during the study period, of which we ringed 14 (Table 2).

A total of 104, 34, 30 and 17 individuals were captured in 2019, 2020, 2021 and 2022, respectively, of which 40, 17, 9 and 4 were ringed for the first time, respectively. In all, 64 (61%), 17 (50%) and 21 (70%) were retraps of birds

Table 2. Number of chicks ringed on Illa de l'Aire during the study period.
Número de polls anellats durant el període d'estudi.

	Nº of chicks ringed			
	2019	2020	2021	2022
<i>Sa Cova</i>	3	2	1	1
<i>Niu de Puffinus</i>	2	1	0	2
<i>Far</i>	0	0	0	0
<i>Bufador</i>	2	0	0	1
<i>Nord</i>	0	0	0	0
Total	7	3	1	4

Table 3. Number of adults ringed and recaptured during the study period.
Número d'adults anellats i recapturats durant el període de estudi.

Ringling year	Nº of birds newly ringed	Ringling year of birds recaptured on 2019	Ringling year of birds recaptured on 2020	Ringling year of birds recaptured on 2021
2022	4	-	-	-
2021	9	-	-	-
2020	17	-	-	2
2019	40	-	5	5
2018	66	15	4	5
2017	30	10	0	1
2016	77	18	2	5
2015	20	7	0	0
2014	3	0	0	0
2013	15	0	0	0
2012	20	2	0	0
2011	10	1	1	0
2010	8	0	0	0
2009	1	0	0	0
2008	37	1	1	0
2007	111	5	3	3
2006	14	1	0	0
2005	17	1	0	0
2004	2	0	0	0
2003	12	0	0	0
2002	3	1	0	0
2001	39	1	0	0
2000	27	1	0	0
1999	0	0	1	0
TOTAL	582	64 (61%)	17 (50%)	21 (70%)

already ringed in previous years (2019, 2020 and 2021, respectively) in the same colony (Table 3). About 98.3% of the recaptures corresponded to birds previously captured in the same area.

In 2019, we captured 58 birds with well-developed incubation patches, 11 birds with signs of incubation patches and 13 birds with no signs of incubation patches. We did not check for incubation patches on 22 individuals. No parasites were recorded in any handled bird during the study period. Interestingly, a bird was ringed in September 2021, a very late date for this species. In July 2021, we recaptured the first adult that had been ringed as a chick on the Illa de l'Aire; it had been ringed in 2019 and this recapture

thus confirms that birds return to their natal colonies in their third calendar year.

The estimated numbers of birds present at Sa Cova and Bufador in 2019 (Table 4) indicate a minimum population size of 76–424 birds on the island. The counts at Bufador suggest a decline in the population at this site in 2021 and 2022 compared to the previous two years, which agrees with the number of nests found (Table 1).

We obtained records of four complete foraging trips with 333 locations. The maximum distance travelled from the colony was almost 400 km and in total the average distance travelled during each trip was 1,159 km in just 3–4 days (Fig. 2).

Table 4. Number of adults ringed and recaptured on two consecutive days, which was used to estimate population size by applying the Lincoln-Petersen method. n1: caught and marked on first occasion; n2: caught on second occasion; m2: caught on both occasions.

Nombre d'adults anellats i recapturats en els dos dies consecutius de captura per estimar la mida de la població aplicant el mètode Lincoln-Petersen. n1: individus capturats i marcats en la 1a ocasió; n2: capturats en la 2a ocasió; m2: capturats en les dues ocasions.

Area	Year	n1	n2	m2	Number of individuals (CI 95%)
Sa Cova	2019	12	11	1	51 (25–155)
Bufador	2019	14	17	1	134 (66–269)
	2020	19	15	1	159 (79–319)
	2021	22	12	4	60 (36–149)
	2022	8	19	1	89 (44–179)

Discussion

During this study, a considerable effort was made to find new breeding colonies in Menorca and as a result we are confident that no other medium-sized or large breeding colony currently exists on or around this island other than on Illa de l'Aire. However, as the species breeds in remote and often inaccessible islets and burrows, it is all but impossible to rule out the existence of other small breeding colonies or isolated breeding pairs as occurs on some small islets off Ibiza (García & Arbona 2007). Moreover, we consider that successful breeding by storm-petrels in previously occupied areas

such as Bleda (Aguilar 1991) are currently impossible given the presence of rats.

The estimation of the breeding population on Illa de l'Aire was not easy, above all due to the inaccessibility of much of this island. Although the maximum number of nests recorded there during the survey was 33 in 2019, the actual number of nests was probably much higher as indicated by the large number of individuals estimated to be present at Sa Cova and Bufador by the Lincoln-Petersen estimator in 2019 (91–588 birds corresponding to 45–294 breeding pairs). However, caution is required when interpreting these results as the application of this estimator is subject to several constraints. First of all, our sample sizes were small, which implies very large confidence intervals. Second, and most importantly, although our results showed that 70% of captured birds in 2019 had well-developed incubation patches and were probably breeding on Illa de l'Aire, the remaining birds could just have been visitors or prospecting the area. Moreover, some authors state that incubation plate vascularization does not necessarily represent clear evidence of reproductive status in birds caught in nets (Cadiou 2016). However, albeit highly variable, it does seem that in the Mediterranean the percentage of non-breeding visitors to colonies is lower than in the Atlantic (Sanz-Aguilar *et al.* 2010). Considering that about 30% of the individuals caught could be non-breeders, we can thus estimate roughly that the breeding population on Illa de l'Aire ranged between a minimum of 64 and a maximum of 411 birds in 2019 (32–206 breeding pairs). Another consideration is whether the studied population is actually a closed population or whether some of the po-

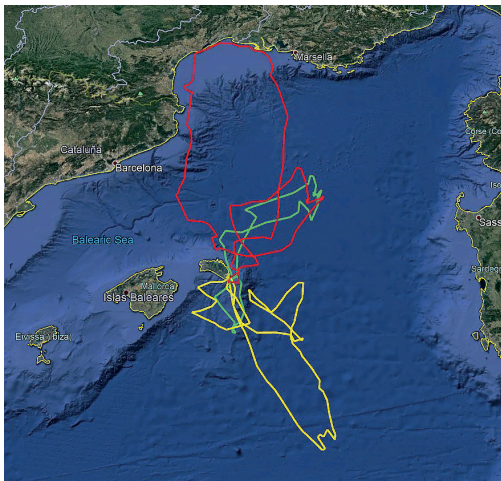


Figure 2. Trajectories of the four birds with GPS devices showing the areas used during the incubation period.

Trajectòries dels quatre marinerets amb GPS que mostren les àrees visitades durant la incubació.

tential breeding birds come from other colonies. Even though movements between colonies have been reported (Sanz-Aguilar *et al.* 2019a), such movements occur rarely and basically involve non-breeders and so for the purpose of this study we considered the use of the Lincoln-Petersen estimator to be justified. Despite being subject to several biases, our estimates indicate for the first time that Illa de l'Aire hosts an important breeding colony of Mediterranean Storm-petrel.

Although more than 500 Mediterranean Storm-petrels have been ringed on Illa de l'Aire since 1991 during the standard ringing campaigns run by the Societat Ornitològica de Menorca, this was the first time that nests had been monitored and storm-petrel chicks had been handled on the island, which opens up the possibility of setting up a monitoring program for gathering fresh information regarding the breeding biology of this species. Although we failed to encourage Storm-petrels to use nest boxes, if successful this would improve our ability to monitor and safeguard the breeding population of storm-petrels on Illa de l'Aire.

Even though only a few individuals were marked, GPS devices provided very interesting information on individual foraging behaviour during the breeding season of birds from this colony, which is the easternmost in the Balearic Islands and the furthest from the coast of the Iberian Peninsula and from previously known main feeding areas (Bécares *et al.* 2011, Rotger *et al.* 2021). Further analysis of this data and comparisons with data obtained from other colonies may contribute to a better understanding of individual foraging behaviour in this species.

Annual monitoring of this species allowed us to evaluate its conservation status on Illa de l'Aire, which has recently been declared a marine Special Bird Protection Area (ZEPA) and an Area of Community Interest (LIC), among other protection figures. The counts conducted at the four areas in 2019–2022 suggest there has been a decline in the number of birds present on the island, a trend that will have to be confirmed or contradicted by future monitoring. Many negative factors threaten the future of this colony and may be responsible for these fluctuations and/or decline. The rabbit, which was introduced many years ago, has been mentioned as a potential competitor or predator of storm-petrels (Sanz-Aguilar *et al.* 2019a) and in some areas there are signif-

icant numbers of Rock dove *Columba livia* that may also compete for breeding sites (Santana 2008). The Yellow-legged gull does not breed in significant numbers near the known breeding grounds of Mediterranean Storm-petrel, so this species is probably not a hindrance to breeding as occurs elsewhere (Mínguez 1994, Oro *et al.* 2005). However, in 2021 we found a gull pellet containing the remains of a storm-petrel, so more data is needed to elucidate the potential negative effect of this gull on storm-petrels. There seems to be no strong competition for breeding sites with other seabirds such as Scopoli's shearwater and Yelkouan or Balearic shearwater inhabiting the same areas. Finally, although the island is currently uninhabited, visitor numbers in summer are growing (up to 100 boats anchored off the island) and this presence and, especially, of unleashed dogs, could have a serious negative effect on the storm-petrels and other breeding seabirds.

Acknowledgements

Many people assisted with this project and I would especially like to thank Monica Orfila and Raül Escandell for their constant logistical support, as well as the ringers from SOM, ARANZADI and ICO. Special mention is also due to Nerea Pagaldai, Nere Zorroza and Lidia López for their intense work in May 2019 that enabled us to obtain the capture-recapture data. Thanks too to the ICO ringer Aida Sabaté for the field days and help with the data-processing, and to the support provided by Richard Barnes, Naomy Toomey, Daniel Oro and Meritxell Genovart from CEAB (CSIC) and Ana Sanz and Andreu Rotger from IMEDEA (CSIC-UIB). This work has benefited from the comments of an anonymous reviewer. I am also very grateful to the owner of the island, Autoritat Portuària de Balears, the Conselleria de Medi Ambient i Territori del Govern de les Illes Balears, Sant Lluís Town Council, the Menorca Preservation Fund and all the volunteers for their nautical support that helped so much during the field work.

Resum

Mida de la població i ecologia reproductiva de l'ocell de tempesta *Hydrobates pelagicus melitensis* a l'Illa de l'Aire, Menorca

El marineret o ocell de tempesta és una petita au marina àmpliament distribuïda per Europa. La primera descripció registrada de l'espècie a Menorca va ser

l'any 1957. La cria de l'espècie es va confirmar a l'Illa de l'Aire l'any 1991. Es coneix molt poc de la mida de la població reproductora i dels paràmetres de cria de l'espècie a Menorca, i aquests es basen en observacions puntuals. Els objectius principals del present estudi són: 1) identificar colònies reproductores de l'espècie a Menorca; 2) obtenir una estimació de la mida de la població reproductora a l'Illa de l'Aire; 3) obtenir informació de reproducció de l'espècie i valorar la possibilitat d'establir un programa de seguiment de la cria a l'Illa de l'Aire. S'ha dedicat un esforç considerable per trobar noves colònies de cria, però no s'han trobat altres zones a part de l'Illa de l'Aire on s'hi han detectat quatre nuclis reproductors. Durant l'estudi es van fer un total de 185 captures i es van anellar un total de 70 exemplars. La mida mínima de la població estimada a l'Illa de l'Aire el 2019, any amb més efectius reproductors durant el període d'estudi, va ser de 33 parelles reproductores, però tots els resultats indiquen que la població és molt més gran, ja que la majoria dels individus crien en zones inaccessibles. Tot i que la recopilació de dades d'aquesta espècie i l'accés a les zones de cria és difícil, considerem que seria interessant i factible establir un seguiment anual en aquesta illa per avaluar la tendència de la població i garantir-ne la seva conservació.

Resumen

Tamaño poblacional y ecología reproductiva del paíño mediterráneo *Hydrobates pelagicus melitensis* en la Illa de l'Aire, Menorca

El paíño europeo es una pequeña ave marina ampliamente distribuida por Europa. La primera descripción registrada de la especie en Menorca fue en 1957. La cría de la especie se confirmó en la Illa de l'Aire en 1991. Se sabe muy poco del tamaño de la población reproductora y de los parámetros de cría de la especie en Menorca, y éstos se basan en observaciones puntuales. Los objetivos principales del presente estudio son: 1) identificar colonias reproductoras de la especie en Menorca; 2) obtener una estimación del tamaño de la población reproductora en la Illa de l'Aire; 3) obtener información de reproducción de la especie y valorar la posibilidad de establecer un programa de seguimiento de la cría en la Illa de l'Aire. Se ha dedicado un esfuerzo considerable por encontrar nuevas colonias de cría, pero no se han encontrado otras localidades aparte de la Illa de l'Aire donde se han detectado cuatro núcleos reproductores. Durante el estudio se capturaron un total de 185 capturas y se anillaron un total de 70 ejemplares. El tamaño mínimo de población estimada en la Illa de l'Aire en 2019, año con más efectivos reproductores durante el período de estudio, fue de 33 parejas reproductoras,

pero todos los resultados indican que la población es mucho mayor puesto que la mayoría de los individuos crían en zonas inaccesibles. Aunque la recopilación de datos de esta especie y el acceso a las zonas de cría es difícil, consideramos que sería interesante y factible establecer un seguimiento anual en estos cuatro núcleos para evaluar la tendencia de la población y garantizar su conservación.

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