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Unusual foraging patterns of the barn owl, *Tyto alba* (Strigiformes: Tytonidae), on small islets from the Pityusic archipelago (Western Mediterranean Sea)

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Abstract. Research on the diet of barn owls on some of the lesser Pityusic Islands (Formentera, s'Espalmador and s'Espartar) reveals a previously undescribed opportunistic trophic behaviour based on regular foraging in patches of territory separated by relatively broad sea channels. Individually, small islets with reduced human influence do not usually provide enough food for the barn owl. Consequently, the species expands its home range to include multiple islands or islets. This study is the first to document the regular crossing of broad sea channels (one of which exceeds 4.5 km) by barn owls in order to hunt. The islets provide the barn owls with prey otherwise considered as marginal (such as *Oryctolagus cuniculus* and *Hydrobates pelagicus*).

Key words: opportunistic behaviour, diet, Formentera, European storm petrel, human arrival, home range

Introduction

Three owl species currently breed on the Pityusic Islands (Eivissa, Formentera and surrounding islets, western Mediterranean Sea): the barn owl, the long-eared owl, *Asio otus*, and the European scops owl, *Otus scops*. Of these, the only one to have been found in the Pityusic Upper Pleistocene and Holocene fossil record is the scops owl (Guerra et al. 2013).

Before the arrival of humans, no terrestrial mammals were present on the Pityusics (Bover et al. 2008, Bover & Alcover 2008), making these islands the largest territory in the entire Mediterranean region without terrestrial mammals. The absence of the barn owl's principal prey (i.e. terrestrial small mammals) must have had consequences on the past presence of the barn owl in the Pityusics (Guerra et al. 2013). The complete absence of fossil barn owl bones from the vast paleornithological record of the Pityusic Islands suggests that the barn owl successfully colonized or substantially increased its population on these islands only after the arrival of humans and the coeval introduction of small mammals, beginning roughly 4150-4350 years ago (i.e. 2150-2350 BC, Alcover 2008).

There is a general consensus that barn owls select their territories, and that they displays an opportunistic hunting behaviour within them (Herrera 1974, Bond et al. 2004, Figueroa et al. 2009). The home range of the barn owl has been estimated to be 3 to 28 km^2 (Taylor 1989, Bond et al. 2004, Martínez & Zuberogoitia 2004), being an irregular area extending a maximum of 3 km from the nest or roost (Andrews 1990). The analysis of owl pellets from some of the small Pityusic Islands presented here sheds light on two poorly known topics: 1) the foraging behaviour of the barn owl on small islets, and 2) the importance for barn owls on the islets of prey species otherwise considered as marginal.

Material and Methods

We have studied barn owl pellets from five localities in the Pityusic Islands (Fig. 1). Localities 1 to 3 correspond to two small Pityusic islets (s'Espalmador

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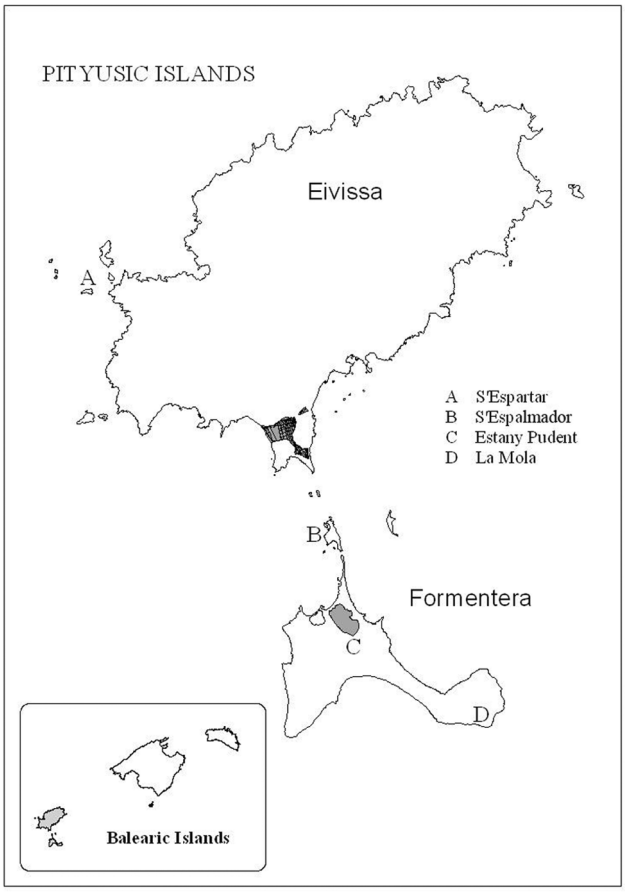

Fig. 1. Map of localities. (A) s'Espartar islet. The site is located at the NE corner of the islet. (B) s'Espalmador islet. The two sites are 50 m apart, on the east of the islet. (C) Quarry close to s'Estany Pudent, Formentera. (D) Torrent des Serverer, La Mola, Formentera.

– with two sites only about 50 m apart, here named "old nest" or locality 1 and "recent nest" or locality 2, and s'Espartar, locality 3). Localities 4 and 5 provide new data from two localities in Formentera (Estany Pudent and La Mola). This island (82 km^2) is the smallest of the inhabited Pityusic Islands. s'Espalmador (c. 2 km^2), close to Formentera, is a flat island with some cliffs on its western coast. Its northern point is 4.5 km from Eivissa. s'Espartar (1900 m^2) is situated 1.3 km from Eivissa (570 km^2). The samples are presented in Table 1, and include complete owl pellets (localities 2, 3 and 5), recently disaggregated pellets (localities 2, 3, 4), and bone concentrations derived from old disaggregated pellets (locality 1). The "old nest" (locality 1) has not been used by barn owls in a long time, and it is documented by a concentration of bones (including bones of prey and bones of barn owl chicks) in a sedimentary layer. Sampling dates for the different sites are presented in Table 1.

The minimum number of individuals of each prey species was estimated on the basis of the best-represented bone in each site. The prey species were identified through direct comparison with bones curated at the IMEDEA (Mediterranean Institute for Advanced Studies) vertebrate reference collection, and using identification keys (Moreno 1985, 1986, 1987). To approach the biomass of consumed prey we used the average weights of rodents and shrews obtained on the Pityusic Islands (from Alcover 1983 PhD thesis and unpublished data). Common rabbit kittens, *Oryctolagus cuniculus* weights were estimated through regression curves (Donázar & Ceballos 1989). The sole mouse-eared bat, *Myotis myotis* found was a young specimen, without fused epiphysis, so it was tentatively assigned a weight of 20 g. For birds, the data of Snow & Perrins (1998) were used. The average weights for reptiles were obtained from lizards from s'Espalmador (V. Pérez-Mellado, pers. comm.).

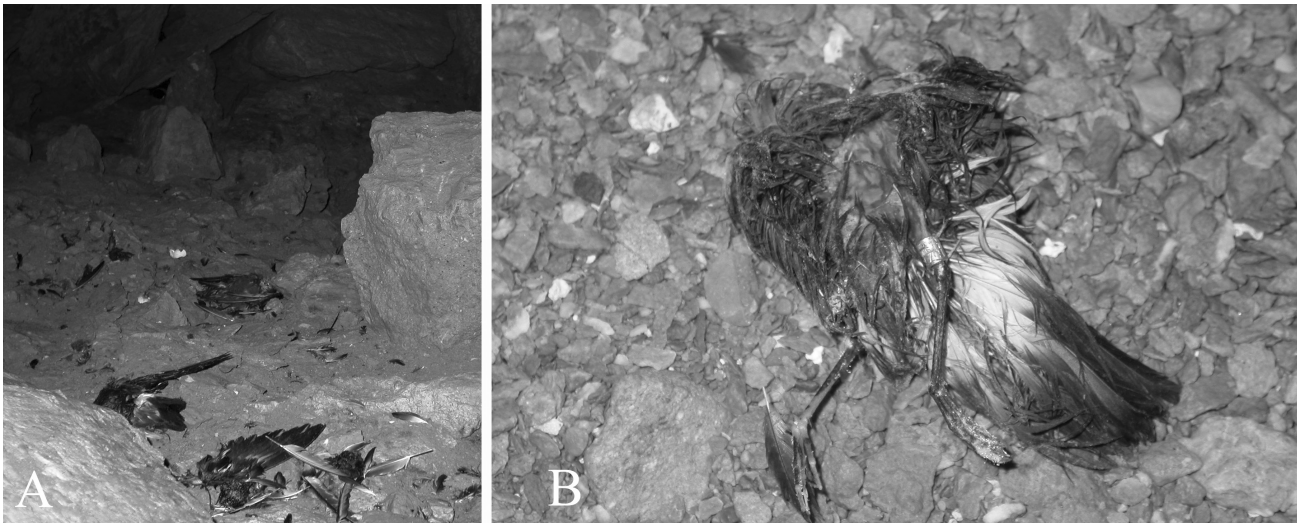

Fig. 2. Remains of *Hydrobates pelagicus* presumably preyed upon by *Tyto alba* at s'Espartar. (A) General view, and (B) detail of a partially consumed ringed specimen. Photographs by David García.

Table 1. Results of the analysis of *Tyto alba* prey from the study localities. 1) s'Espalmador 1, sediment from old nest (June 2009); 2) s'Espalmador 2, recent nest, pellets (January 2006, April 2007, January 2008); 3) s'Espartar (June 2007); 4) Formentera, quarry close to Estany Pudent (November 2007 and December 2008); 5) Formentera, Torrent des Serverer, La Mola (April 1978). All prey obtained are grouped for each locality. Some birds remain unidentified. An average estimate of the weight of the identified birds was used to calculate the biomass (the effectively consumed biomass must have been smaller, because some of the heavier prey were only partially ingested). Percentages do not add up to 100 because of rounding.

	s'Espalmador								s'Espartar				Formentera							
	Old nest				Recent nest				s'Espartar				Estany Pudent				La Mola			
	Number		Biomass		Number		Biomass		Number		Biomass		Number		Biomass		Number		Biomass	
	n	%	Tot	%	n	%	Tot	%	n	%	Tot	%	n	%	Tot	%	n	%	Tot	%
Mammalia																				
Crocidura pachyura	28	3.6	210	0.7	2	1.7	15	0.4	7	21.9	52.5	8.1								
Myotis myotis	1	0.1	20	0.1																
Apodemus sylvaticus	504	64.0	15120	47.5	89	76.1	2670	68.7	1	3.1	30	4.6	19	8.4	570	6.2	25	30.5	750	17.9
Mus musculus													26	11.5	286	3.1	4	4.9	44	1.0
Mus sp.	58	7.4	638	2.0																
Rattus rattus	73	9.3	5475	17.2	10	8.5	750	19.3					27	11.9	2025	22.0	13	15.9	975	23.2
Eliomys quercinus	9	1.1	720	2.3									36	15.9	2880	31.3	22	26.8	1760	42.0
Oryctolagus cuniculus	45	5.7	7650	24.0									1	0.4	170	1.8				
Total	718	91.2	29833	94	101	86.3	3435	88.4	8	25.0	82.5	12.7	109	48.0	5931	64.4	64	78.0	3529	84.1
Aves																				
Hydrobates pelagicus	23	2.9	598	1.9					21	65.6	546	84.1								
Coturnix coturnix	1	0.1	100	0.3																
Charadrius alexandrinus	2	0.3	90	0.3																
Calidris ferruginea	1	0.1	57	0.2																
Tringa sp.	1	0.1	85	0.3																
Chlidonias sp.	1	0.1	80	0.3	1	0.9	80	2.1												
Merops apiaster													1	0.4	58	0.6				
Jynx torquilla	1	0.1	37	0.1									2	0.9	74	0.8				
Calandrella (cf.)	1	0.1	23	0.1																
Calandrella brachydactyla																	1	1.2	23	0.5
Alauda arvensis																	2	2.4	78	1.9
Hirundo rustica													2	0.9	38	0.4				
Anthus pratensis	1	0.1	19	0.1																
Troglodytes troglodytes (cf.)	3	0.4	27	0.1																
Erithacus rubecula	6	0.8	102	0.3	2	1.7	34	0.9					1	0.4	17	0.2				
Erithacus rubecula (cf.)													1	0.4	17	0.2				
Phoenicurus ochruros					1	0.9	16	0.4					29	12.8	464	5.0				

Phoenicurus ochruros (cf.)	1	0.1	16	0.1															
Turdus sp.	2	0.3	200	0.6												1	1.2	100	2.4
Turdus sp. (large size)	1	0.1	120	0.4															
Turdus merula (cf.)													1	0.4	100	1.1			
Turdus/Sturnus	1	0.1	100	0.3															
Sylvia sp.					2	1.7	38	1.0					2	0.9	38	0.4			
Sylvia sp. (cf.)	1	0.1	19	0.1															
Sylvia borin/atricapilla					1	0.9	19	0.5											
Phylloscopus sp.	1	0.1	9	0.0	1	0.9	9	0.2											
Phylloscopus (cf.)	1	0.1	9	0.0															
P. collybita/trochilus					1	0.9	9	0.2											
Muscicapidae (small size)	2	0.3	40	0.1	3	2.6	60	1.5					1	0.4	20	0.2			
Lanius collurio immature (cf.)													2	0.9	54	0.6			
Lanius senator	2	0.3	70	0.2															
Passer domesticus					1	0.9	31	0.8					70	30.8	2170	23.6	5	6.1	155	3.7
Fringilla coelebs	1	0.1	23	0.1															
Fringillidae indet.	3	0.4	90	0.3															
Carduelis chloris					1	0.9	88	2.3					2	0.9	176	1.9	2	2.4	176	4.2
Carduelis carduelis																	2	2.4	32	0.8
Carduelis cannabina	1	0.1	18	0.1									1	0.4	18	0.2	2	2.4	36	0.9
Emberiza sp.													1	0.4	20	0.2				
Passeriformes indet.					2	1.7	66	1.7									2	2.4	66	1.6
Total	58	7.4	1932	6.1	16	13.7	450	11.6	21	65.6	546	84.1	116	51.1	3264	35.4	17	20.7	666	15.9
Reptilia																				
Tarentola mauritanica									2	6.3	14	2.2	1	0.4	7	0.1				
Podarcis pityusensis	10	1.3	70	0.2					1	3.1	7	1.1	1	0.4	7	0.1				
Total	10	1.3	70	0.2	0	0.0	0	0.0	3	9.4	21	3.2	2	0.9	14	0.2	0	0.0	0	0.0
Amphibia																				
Pelophylax perezi	1	0.1	22	0.1																
Total	1	0.1	22	0.1	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Insecta																				
Copris hispanus																	1	1.2		
Total	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	1	1.2	0	0.0
TOTAL	787		31857		117		3885		32		649.5		227		9209		82		4195	

Results and Discussion

In this study 1245 prey individuals were identified. Globally, small mammals represented the most abundant prey (c. 80 %), followed by birds (18.3 %), reptiles (1.2 %) and amphibians (0.08 %, one specimen). The size of the prey varied from more than 100 g (some adult black rats, *Rattus rattus*, adult Formenteran garden dormice *Eliomys quercinus ophiusae*, and juvenile common rabbits, *Oryctolagus cuniculus*; the largest specimen of rabbit must have weighed c. 220 g) to less than 10 g (Moorish geckos, *Tarentola mauritanica*, Eivissan lizards, *Podarcis pityusensis*, North African white-toothed shrews, *Crocidura pachyura*, and some small birds; the smallest prey was close to 7 g).

Small mammals usually represented c. 90 % of prey in Eivissa, the largest of the Pityusic Islands (Rey & Rey 1974, based on 2988 prey individuals; Alcover 1977, on the basis of 5242 prey individuals; Sommer et al. 2005, on the basis of 2755 prey individuals) and in s'Espalmador, but they fell to 48 % in s'Estany Pudent (Formentera), and to 25 % in s'Espartar. At these sites, birds were present in greater numbers than mammals (51.1 % in the Formenteran locality at s'Estany Pudent, and 65.6 % in s'Espartar). Shrews were absent from all the samples from Formentera, while they were present in small percentages (1.7 % to 3.6 %) in s'Espalmador.

Usually rabbits are rarely preyed on by barn owls (e.g. Herrera & Jaksic 1980). Only one among 5242 specimens was obtained by Alcover (1977) in Eivissa, and none by Rey & Rey (1974) and by Sommer et al. (2005). In the old nest on s'Espalmador (locality 1) there were 45 rabbit kittens (5.7 % in number, representing 24 % of the preyed biomass). All rabbits were very young, showing non-fused epiphyses on long bones, with femur length (without the epiphyses) between 30.5 and 48.1 mm, and jaw length mainly between 24 and 25.8 mm (although there was an outsider with a jaw length of 33.6 mm). They had an estimated weight between 140 and 220 g, close to that displayed by rabbit kittens when they leave their burrows for the first time. At that age, kittens are naive regarding predators (Mykytowycz et al. 1959). Thus, the s'Espalmador barn owls probably consumed rabbits only during a short period of the year (in spring, the breeding season of rabbits). The absence of rabbit remains in the recent nest of s'Espalmador (locality 2) correlates with the current absence of rabbits on the islet.

Black rats constituted 9.2 % of the diet of the s'Espalmador barn owls. On the Mediterranean mainland, rats contribute a minor percentage (usually less than 2.5 %) of the barn owl's diet (e.g. Bontzorlos et al. 2005). The garden dormouse did not form part of the diet on Eivissa but it appeared as an important prey item in the Formenteran localities (from 15.9 % in Estany Pudent to 26.8 % in La Mola). On the contrary, at s'Espalmador its presence was very low (c. 1 %).

The presence of bats in the diet of owls is usually very scarce (Speakman 1991, Vernier 1993, García et al. 2005). They rarely appear in barn owl pellets from the Balearic Islands (Rey & Rey 1974, Alcover 1977, de Pablo 2000, Sommer et al. 2005). Here we report a young *Myotis myotis* from the old nest on s'Espalmador (locality 1). This species has never been observed alive in the Pityusics, although it is autochthonous of these islands, as documented by its abundant remains in the Upper Pleistocene-Holocene deposit of es Pouàs, Eivissa (Alcover 2003). In addition, a jaw of one specimen of this species appeared in Cova Xives, Eivissa (Alcover 1984). This finding at s'Espalmador confirms its presence in the recent past.

Birds represented about 18.3 % of the total of consumed prey reported in this paper. One third of the consumed birds corresponded to the house sparrow, *Passer domesticus*. Sparrows are among the birds most frequently preyed upon by the barn owl in the Pityusic Islands, although their significance decreases at the two localities in Formentera and does so to the point of disappearing on lesser islets, where the importance of migratory birds or seabirds increases. Globally, the results of this study supports the hypothesis of Johnston & Hill (1987) that the barn owl diet includes, as an average, a greater number of birds on small islands than on mainland sites. In mainland Spain the proportion of birds in the diet of barn owl is very low (Herrera 1974, Delibes et al. 1984), while in Eivissa it is about 6-7 % or even less (Rey & Rey 1974, Alcover 1977, Sommer et al. 2005).

Foraging behaviour on small islets

The prey assemblages studied here revealed some peculiar characteristics of the foraging behaviour of the barn owl in the lesser Pityusic Islands. In relation to the use of islets as hunting areas, two behavioural strategies can be identified. Sites at s'Espalmador correspond to nesting deposits containing a high number of prey (as well as some bones of barn owl chicks). On the other hand, the s'Espartar site, a roosting place, only delivered a few pellets that could have been deposited by a sole occasional, although recurrent, visitor.

s'Espalmador

The North African white-toothed shrew, *Crocidura pachyura* is useful as a marker for hunting sites used by the barn owls at s'Espalmador. In the Pityusics, shrews are only present on Eivissa (Alcover 1979). Finding the North African white-toothed shrew in different pellets indicates a recurrent hunting behaviour of the s'Espalmador barn owl, involving razzias from s'Espalmador to Eivissa, flying at least 11 km on each occasion: i.e. crossing a gap of 5.5 km (including > 4.5 km over the sea) and, once on the main island, flying inland to reach suitable habitats for shrew and other prey, and later coming back to s'Espalmador. It is generally accepted that barn owls hunt in an area around their nests or roosts of a maximum diameter of c. 2-3 km (Andrews 1990). The recurrent capture of the shrews on Eivissa by the s'Espalmador barn owls documents that, under special circumstances, this species can regularly fly over longer distances.

Some other prey also seemed to have been caught on Eivissa. Two sibling species of mice occur on Eivissa, the Western Mediterranean mouse, *Mus spretus* and the domestic mouse, *Mus musculus*, although only the latter lives on Formentera and s'Espalmador. Following the criteria established by Darviche & Orsini (1982), at least one specimen from s'Espalmador belongs to the Western Mediterranean mouse (thus, it was captured on Eivissa). Other remains from s'Espalmador indicate that "mainland" Eivissa is not the sole hunting area for the barn owl from s'Espalmador. The presence of remains of the European storm petrel, *Hydrobates pelagicus*, absent from s'Espalmador, Formentera and Eivissa, suggest the use of some other islet as a nearby hunting place. Several islets scattered in the sea channel separating Eivissa and Formentera, as well as the s'Espardell islet (c. 3 km from s'Espalmador), contain breeding colonies of the European storm petrel (García & Arbona 2007).

In comparison to more suitable and continuous territories, such as would normally be selected by the barn owl in mainland areas, the hunting habitat fragmentation discussed here (i.e. islets separated by sea channels) implies an increased metabolic cost. The data suggest that barn owls survive at s'Espalmador under conditions of prey shortage that force them to diversify their hunting areas, extending their home range to Eivissa and to other islets. The sea represents an unsuitable hunting area for barn owl, which must fly to reach adequate areas (islands or islets) to catch prey.

The evidence collected in this study indicates that the s'Espalmador barn owls hunt a relatively high number of small birds. The house sparrow, the most abundant bird prey found in Eivissa (Sommer et al. 2005), is scarce in the diet at s'Espalmador. House sparrows mainly forage on cultivated crops and in villages, and neither crops nor villages are present at s'Espalmador (an uninhabited islet), or at Punta des Trucadors in Formentera (the closest site to s'Espalmador). Thus, owls at these sites are lacking a resource that is important in other Pityusic localities (see Sommer et al. 2005 and Formenteran sites in Table 1). Instead of house sparrows, a plethora of migrant species appears in the diet of the s'Espalmador barn owls. The winter pellet assemblages (January 2006 and 2008) contain a high percentage of migrant birds. Among them, the most abundant are the European robin, *Erithacus rubecula* and the black redstart, *Phoenichurus ochrurus*. The diet recorded for s'Espalmador barn owls indicates that they hunt over longer distances than is usual in mainland owls. The crucial point here is that hunting patches are separated by sea channels and this type of hunting behaviour is unusual in this species. These barn owls bred on a small islet (s'Espalmador), while they foraged not only there but also on larger islands (Eivissa and Formentera), and on some of the smaller surrounding islets. A foraging strategy including sporadic overseas displacements between Alegranza and Lanzarote (Canary Islands) has been suggested for the Canarian barn owl, *Tyto alba gracilirostris* although it remains unproven (Siverio & Palacios 2004).

s'Espartar

Diet analysis at s'Espartar reveals a different behavioural strategy. Barn owls do not breed at s'Espartar. The pellet assemblage recovered there is small, comprising only 14 complete pellets, suggesting a short depositional period, close to the time of their collection. The pellet contents at s'Espartar included remains of European storm petrel as well as of shrews and of a specimen of field mouse, *Apodemus sylvaticus*. The last two species are not present at s'Espartar and they must therefore have been captured on the Eivissan mainland (about 1.3 km from s'Espartar). As shrews were found in different pellets, the pellet assemblage documents a recurrent crossing of the sea channel. The owl pellets were found at the entrance of a cave at s'Espartar where there is a colony of European storm petrels. In this case, in contrast to s'Espalmador, the evidence points to a barn owl living and breeding on Eivissa and visiting s'Espartar occasionally to hunt.

Storm petrels as a prey of the barn owl

Until now, only Araujo et al. (1977) in Cabrera, Delgado (1993) and Delgado et al. (1992) in Montaña Clara and Alegranza (Canary Islands) had reported *H. pelagicus* as an occasional prey of the barn owl. Such scarce data suggest that hunting of European storm petrels by barn owls has not been sufficiently studied or is uncommon. The data presented here add some behavioural information. The breeding success of the European storm petrel is affected by the presence of rats, so it usually breeds on islands free of rats (de León et al. 2006). s'Espartar is an islet free of rats with a breeding colony of these birds (García-Gans et al. 2005). s'Espalmador, on the contrary, is a rat-infested islet and does not harbour a breeding colony of petrels (Ruffino et al. 2009), although several small islets nearby, such as s'Espardell (3 km apart) and some other islets at es Freus, do (García & Arbona 2007). s'Espartar is used sporadically as a hunting area by a barn owl that breeds on Eivissa, while s'Espalmador is the base of a couple that forages on small islets with breeding colonies of European storm petrels. In the latter case, the barn owl visits one or more colonies, but without detected roosting on the islets where the petrels breed (i.e. returning back home, to s'Espalmador, and regurgitating the pellets there). Although European storm petrels could presumably have been captured flying over the sea, this behaviour has never been reported anywhere, and can be dismissed as being highly improbable. The evidence from s'Espartar suggests that the barn owl catches petrels on land, while they are on the ground near the entrance of their breeding colony. On June 21, 2006, > 30 specimens of European storm petrels were found dead inside a cave (see Fig. 2) at s'Espartar (locality 3). Barn owls appeared to be the most probable cause of death of these specimens, all partially consumed, since no other potential predator able to visit caves (such as cats or rats) were detected on the islet. This attribution agrees with the documented presence of storm petrels in the owl pellets obtained at the entrance of the cave. The location of the remains of storm petrels inside the cave implies that the barn owl had entered on foot through a short, low, and narrow corridor to kill the storm petrels close to their nests in a dim light zone.

Additionally, a barn owl pellet containing remains of European storm petrels has been found at Illa Murada, another Pityusic small islet without rats, 1.75 km^2, c. 200 m from Eivissa, and containing a breeding colony of petrels (J. Mayol, pers. comm.). Thus, the predation on European storm petrels, although sporadic, seems to be more frequent than previously considered. The actual impact of barn owl predation on the breeding colonies of the European storm petrel on the Pityusics remains to be evaluated.

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Literature

Alcover J.A. 1977: The long-tailed field mouse or wood mouse *Apodemus sylvaticus* (Linné, 1758) from the island of Ibiza, Pityusics. *Säugetierk. Mitt. 25: 204–213.*

Alcover J.A. 1979: Els mamífers de les Balears. *Manuals d'Introducció a la Naturalesa*, *2nd ed. Moll, Palma de Mallorca.*

Alcover J.A. 1983: Contribució al coneixement dels mamífers de les Balears i Pitiüses. *PhD thesis, University of Barcelona, Barcelona.*

Alcover J.A. 1984: Subrecent small mammal fauna of Eivissa. In: Kuhbier H., Alcover J.A. & Guerau d'Arellano C. (eds.), Biogeography and ecology of the Pityusic Islands. *Monograph. Biol. 56: 377–392.*

Alcover J.A. 2003: Les rates pinyades fòssils (Mammalia, Chiroptera) del jaciment paleontològic des Pouàs (Sant Antoni de Portmany, Eivissa). *Endins 25: 141–154.*

Alcover J.A. 2008: The first Mallorcans: prehistoric colonization in the Western Mediterranean. *J. World Prehist. 21: 19–84.*

Andrews P. 1990: Owls, caves and fossils. *Natural History Museum Publications, London.*

Araujo J., Purroy F.J. & Muñoz-Cobo J. 1977: Las rapaces y aves marinas del Archipiélago de Cabrera. *Nat. Hisp. 12: 1–94.*

Bond G., Burnside N.G., Metcalfe D.J., Scott D.M. & Blamire J. 2004: The effects of land-use and landscape structure on barn owl (*Tyto alba*) breeding success in southern England. *Landscape Ecol. 20: 555–566.*

Bontzorlos V.A., Peris S.J., Vlachos C.G. & Bakaloudis D.E. 2005: The diet of barn owl in the agricultural landscapes of central Greece. *Folia Zool. 54: 99–110.*

Bover P. & Alcover J.A. 2008: Extinction of the autochthonous small mammals of Mallorca (Gymnesic Islands, Western Mediterranean) and its ecological consequences. *J. Biogeogr. 35: 1112–1122.*

Bover P., Quintana J. & Alcover J.A. 2008: Three islands, three worlds: paleogeography and evolution of the vertebrate fauna from the Balearic Islands. *Quat. Internat. 182: 135–144.*

Darviche D. & Orsini P. 1982: Critères de différenciation morphologique et biométrique de deux espèces de souris sympatriques: *Mus spretus* et *Mus musculus domesticus*. *Mammalia 46: 205–217.*
de León A., Mínguez E., Harvey P., Meek E., Crane J.E. & Furness R.W. 2006: Factors affecting breeding distribution of storm-petrels *Hydrobates pelagicus* in Orkney and Shetland: the main factors are past and present human activities, especially the introduction of rats to islands. *Bird Study 53: 64–72.*
de Pablo F. 2000: Alimentación de la lechuza común (*Tyto alba*) en Menorca. *Boll. Soc. Hist. Nat. Balears 43: 15–26.*
Delgado G. 1993: Variación estacional de la dieta de *Tyto alba gracilirostris* (Hartert, 1995) en la isla de Alegranza (Lanzarote, Islas Canarias) (Aves: Tytonidae). *Vieraea 22: 133–137.*
Delgado G., Carrillo J. & Trujillo D. 1992: Sobre la presencia y distribución de la lechuza común (*Tyto alba* Scopoli, 1769) en las islas orientales del Archipiélago Canario. *Vieraea 21: 145–148.*
Delibes M., Brunet-Lecomte P. & Máñez M. 1984: Datos sobre la alimentación de la lechuza común (*Tyto alba*), el buho chico (*Asio otus*) y el mochuelo (*Athene noctua*) en una misma localidad de Castilla la Vieja. *Ardeola 30: 57–63.*
Donázar J.A. & Ceballos O. 1989: Selective predation by eagle owls *Bubo bubo* on rabbits *Oryctolagus cuniculus*: age and preferences. *Ornis Scand. 20: 117–122.*
García D. & Arbona P. 2007: Nuevas localidades de nidificación del Paiño Europeo *Hydrobates pelagicus* en el Parc Natural de Ses Salines d'Eivissa i Formentera (Islas Pitiüses-Baleares). *An. Ornit. Balears 22: 81–83.*
García M., Cervera F. & Rodríguez A. 2005: Bat predation by long-eared owls in the Mediterranean and temperated regions of southern Europe. *J. Raptor Res. 39 (4): 445–453.*
García-Gans F.J., Santana C., Tornero J.A. & Català F.J. 2005: Resultats preliminars de la quantificació de la població reproductora d'Ocell de tempesta *Hydrobates pelagicus melitensis* de l'illot de s'Espartar. *An. Ornit. Balears 19: 45–49.*
Guerra C., McMinn M. & Alcover J.A. 2013: The Upper Pleistocene-Holocene raptorial bird guild from Eivissa Island (Pityusic Archipelago, Western Mediterranean Sea). *Geobios 46: 491–502.*
Figueroa R.A., Rau J.R., Mayorga S., Martínez D.R., Corales E.S., Mansilla A. & Figueroa R. 2009: Rodent prey of the barn owl *Tyto alba* and short-eared owl *Asio flammeus* during winter in agricultural lands of southern Chile. *Wildlife Biol. 15: 129–136.*
Herrera C.M. 1974: Régimen alimenticio de *Tyto alba* en España sudoccidental. *Ardeola 19: 359–394.*
Herrera C.M. & Jaksic F.M. 1980: Feeding ecology of the barn owl in Central Chile and Southern Spain: a comparative study. *Auk 97: 760–767.*
Johnston D.W. & Hill J.M. 1987: Prey selection of common barn-owls on islands and mainland sites. *J. Raptor Res. 21: 3–7.*
Martínez J.A. & Zuberogoitia I. 2004: Habitat preferences and causes of population decline for barn owls *Tyto alba*: a multi-scale approach. *Ardeola 51 (2): 303–317.*
Moreno E. 1985: Clave osteológica para la identificación de los Passeriformes ibéricos. I. Aegithalidae, Remizidae, Paridae, Emberizidae, Passeridae, Fringillidae, Alaudidae. *Ardeola 32: 295–377.*
Moreno E. 1986: Clave osteológica para la identificación de los Passeriformes ibéricos. II. Hirundinidae, Prunellidae, Sittidae, Certhiidae, Troglodytidae, Cinclidae, Laniidae, Oriolidae, Corvidae, Sturnidae, Motacillidae. *Ardeola 33: 69–129.*
Moreno E. 1987: Clave osteológica para la identificación de los Passeriformes ibéricos. III. Muscicapidae. *Ardeola 34: 243–273.*
Mykytowycz R., Hesterman E.R. & Purchase D. 1959: Predation of the wild rabbit by the Australian raven. *Emu 59: 41–43.*
Rey J.C. & Rey J.M. 1974: Nota preliminary sobre las musarañas del género *Crocidura* Wagler, 1832 en las islas Baleares. *Bol. Est. Centr. Ecol. 3: 9–16.*
Ruffino L., Bourgeois K., Vidal E., Deum C., Paracuellos M., Escribano F., Sposimo P., Baccetti N., Pascal M. & Oro D. 2009: Invasive rats and seabirds after 2000 years of an unwanted coexistence on Mediterranean islands. *Biol. Invasions 11: 1631–1651.*
Siverio F. & Palacios C.J. 2004: Lechuza común *Tyto alba* gracilirostris. In: Madroño A., González C. & Atienza J.C. (eds.), Libro rojo de las aves de España. *Dirección general para la biodiversidad-SEO/BirdLife, Madrid: 286–288.*
Snow D.W. & Perrins C.M. 1998: The birds of the Western Palaearctic. *Oxford University Press, New York.*
Sommer R., Zoller H., Kock D., Böhme W. & Griesau A. 2005: Feeding of the barn owl, *Tyto alba* with first record of the European free-tailed bat, *Tadarida teniotis* on the island of Ibiza (Spain, Balearics). *Folia Zool. 54: 364–370.*
Speakman J.R. 1991: The impact of predation by birds in bat populations in the British Isles. *Mammal Rev. 21 (3): 123–142.*
Taylor I.R. 1989: The barn owl. *Shire Publications, Aylesbury.*
Vernier E. 1993: Predazione di Chirotteri da parte del Barbagianni (*Tyto alba*) in Italia. *Hystrix 5: 105–107.*