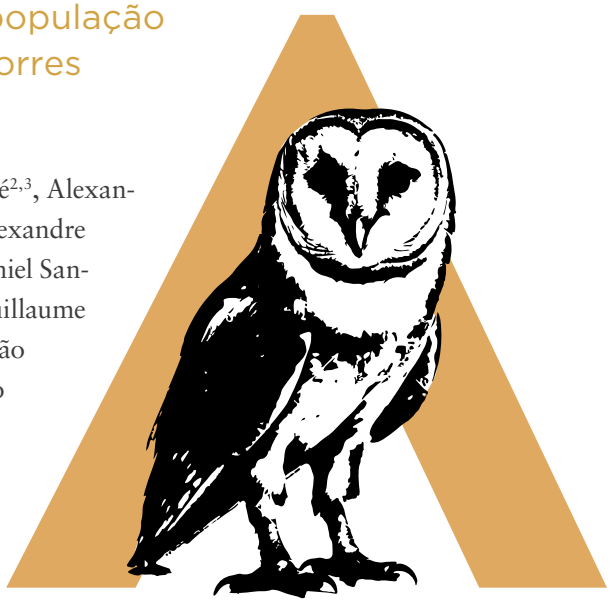
First national census of the Common Barn-owl (*Tyto alba*) breeding population in Portugal

Primeiro censo nacional da população reprodutora de Coruja-das-torres (*Tyto alba*) em Portugal



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ABSTRACT

The Common Barn-owl *(Tyto alba)* is a cosmopolitan farmland bird that has disappeared from almost 50% of its range in mainland Portugal in the last decade. In order to improve estimates of the distribution and population abundance of the species, and contribute to understanding its long-term population trend, we carried out the First National Census of the Common Barn-owl Breeding Population. The census included two different methodologies: systematic point counts with playback broadcasts carried out by experienced volunteers, organised by regional coordinators, and a non-systematic census open to the general population, which consisted of passive listening point counts and an online survey. The systematic census involved 24 regional coordinators and 268 volunteers, who carried out 1 131 point counts in mainland Portugal, resulting in 340 Barn-owl records (detection frequency of 30%). The non-systematic census included 150 point counts and 414 surveys. In total, 405 Barn-owl observations were recorded, 61 at the point counts and 344 in the surveys, also covering the autonomous region of Madeira. Combining this information with the records from PortugalAves/eBird, the Barn-owl was detected in 399 10x10 km squares in mainland Portugal and 11 in the Madeira archipelago, resulting in a population estimate of 800 to 5,000 breeding pairs. Both census methods had their advantages, and we suggest they should be replicated with adaptations in future editions. This census established the baseline for future national censuses of the Barn-owl, which will enable the estimation of long-term population trends.

Keywords: Citizen science; Online survey; Point counts; Population estimate

RESUMO

A Coruja-das-torres *(Tyto alba)* é uma ave cosmopolita, típica de áreas agrícolas, que desapareceu de quase 50% da sua área de distribuição em Portugal continental na última década. Para melhorar as estimativas da distribuição e abundância populacional da espécie, e contribuir para a compreensão da sua tendência populacional a longo prazo, realizámos o Primeiro Censo Nacional da População Reprodutora de Coruja-das-torres. A metodologia do censo compreendeu dois níveis de especialização: pontos de escuta sistemáticos com emissão de vocalizações conspecíficas, realizados por voluntários com experiência e organizados por coordenadores regionais, e um censo não sistemático aberto à população em geral, que consistiu em pontos de escuta espontânea e um inquérito online. No censo sistemático participaram 24 coordenadores regionais e 268 voluntários, que realizaram 1.131 pontos de escuta em Portugal Continental, resultando em 340 registos de coruja-das-torres (frequência de deteção de 30%). O censo não sistemático incluiu 150 pontos de escuta e 414 inquéritos. No total, foram registadas 405 observações de Coruja-das-torres, 61 nos pontos de escuta e 344 nos censos, que abrangeram também a Região Autónoma da Madeira. Combinando a informação obtida no campo com a informação registada no PortugalAves/eBird, foi detetada a presença da Coruja-das-torres em 399 quadrículas de 10x10 km em Portugal Continental e 11 no arquipélago da Madeira, resultando numa estimativa populacional entre 800 e 5.000 casais reprodutores. Ambos os métodos de censo tiveram as suas vantagens, pelo que sugerimos que sejam mantidos e adaptados em edições futuras. Este censo permitiu construir a base de referência para futuros censos nacionais da Coruja-das-torres, que irão possibilitar a estimativa da tendência populacional a longo prazo.

Palavras-chave: Ciência-cidadã; Estimativa populacional; Inquéritos; Pontos de escuta

Introduction

The Common Barn-owl (*Tyto alba*, hereafter Barn-owl) is a cosmopolitan farmland bird, easily recognisable by its distinctive heart-shaped white facial disc and predominantly white underparts, and resident throughout mainland Portugal and the Madeira archipelago (Equipa Atlas 2023). It hunts preferentially in open areas, such as agricultural fields, pastures, and open forests, while avoiding dense woodlands and extensive of scrubland. It also occupies urban areas, often nesting in built structures, and is very tolerant to human presence (Bunn et al. 1982, Roulin 2002). However, its occurrence in humanised landscapes makes it highly susceptible to habitat changes leading to food shortages, loss of roosting and nesting sites and other anthropogenic risks, which is causing declines in several populations across Europe (de Bruijn 1994, Newton et al. 1996, Fajardo 2001, Martínez & Zuberogoitia 2004, Barn-owl Trust 2012, Roque et al. 2022).

In the Iberian Peninsula, the Barn-owl has been monitored through volunteer-based national monitoring schemes in Portugal (since 2009) and Spain (since 1997), which estimate a short-term decreasing population trend (GTAN-SPEA 2023, Escandel & Escudero 2022), consistent with the current trend in Europe (BirdLife International 2022, EIONET 2022). The latest Portuguese Breeding Bird Atlas signals the disappearance of the Barn-owl from almost 50% of its range in the last decade, while maintaining a country-wide distribution (Equipa Atlas 2023). Consequently, its IUCN category increased from Least Concern to Nearly Threatened in the latest Portuguese Red List of Birds (Almeida

et al. 2022). To improve estimates of the distribution and population abundance of the Barn-owl in Portugal, and to contribute for a long-term population trend assessment, we conducted the First National Census of the Common Barn-owl Breeding Population. Repeating this census on a regular basis can provide a more reliable assessment of the population and distribution trends at shorter intervals than those provided by bird atlases. This information is fundamental for implementing timely conservation measures.

A previous targeted owl census, involving regional coordinators who made decisions about the priority sites for sampling and mobilised trained volunteers, was successfully conducted in mainland Portugal in 2022, to estimate the wintering population of the Short-eared Owl (*Asio flammeus*), which has a limited distribution in the country (Tomé et al. 2022). In our Barn Owl census, given (1) the importance of engaging a wide range of participants to survey potentially suitable areas for the species across the country, and (2) the ease of identifying the species, we implemented a complementary science education initiative involving schools, organized groups (such as scouts and other non-profit organizations), and the general public as part of the census effort. In addition, we have adopted an inclusive approach to the census, encouraging the participation of untrained volunteers, through a simplified methodology and reporting process.

This census was a citizen science initiative promoted by the Portuguese Society for the Study of Birds (SPEA) and the University of Évora's Laboratory of Ornithology (LabOr-MED). It combined two methodologies: a systematic census, which followed a standard methodology and quantified sampling effort, representing the basic approach, and a non-systematic census, which tested a complementary methodology, aimed at engaging new volunteers in bird census. Complementarly, we incorporated records from eBird into the census data. In this article, we report and combine the results of both census approaches, analyse their strengths and limitations, and provide the most accurate national population estimate for the Barn-owl, which will serve as the basis for future targeted censuses.

Methods

To map Barn-owl distribution and calculate the population estimate for 2023, the information obtained from the systematic and non-systematic censuses was integrated in GIS (QuantumGIS) with records from the PortugalAves/eBird platform (eBird 2023) from January to July of that year. This online platform requires birdwatchers to submit observations for specific dates and locations, including counts of all seen or heard species, using standardized protocols which include stationary, travelling, incidental, and historical observations.

All Barn-owl observations, either entered by volunteers of the systematic and non-systematic census or other birdwatchers (eBird), were considered. The minimum number of pairs was estimated by analysing in GIS the spatial overlap of the observations within 10x10 km squares (geodetic datum ETRS89). To avoid overestimation of potential breeding pairs by double counting, observations from any source (systematic and non-systematic censuses and eBird) that were less than 1 km apart were considered as the same potential territory/breeding pair, except when clearly stated by experienced volunteers as different territories (i.e., two birds detected too far away to be considered one pair) or when more than two individuals were observed in the same location. We then counted the minimum number of potential territories/breeding pairs in each ETRS 10x10 km square for which there were records. To determine the lower limit of the population estimate, we summed the minimum number for each square. To determine the upper limit, i.e., the maximum number of pairs, first we calculated the number of squares with Barn-owl presence in 2023. Then, the total number of

10x10 km squares with presence was multiplied by the potential maximum number of breeding pairs per square as corresponding to the best available estimate, i.e., the upper confidence interval for Barn-owl abundance of 12.14 pairs/100 km² in mainland Portugal provided in Lourenço et al. (2015).

Results

A total of 24 regional coordinators and 268 volunteers contributed to the systematic census, carrying out 1 131 point counts in mainland Portugal. The number of point counts per district ranged from six (Vila Real) to 163 (Lisbon; Table 1). A total of 340 Barn-owl records were obtained, corresponding to a detection frequency of 30% (i.e., proportion of point counts with at least one Barn-owl detected). The detection frequency varied by district ranging from 13% (Castelo Branco) and 61% (Coimbra; Figure 1).

The non-systematic census included 414 questionnaires and 150 point counts. In total, 405 Barn-owl observations were recorded, 344 in the questionnaires and 61 at point counts (Table 2). These results include the autonomous region of Madeira, where five Barn-owl locations were submitted in surveys and 15 from point counts (Table 2). Data from the questionnaires showed that the number of Barn-owl locations per district ranged from five (Bragança) to 48 (Santarém), while owl records from point counts ranged from zero (Castelo Branco, Coimbra, Guarda, Viana do Castelo and Vila Real) to 61 (Santarém; Figure 2).

Figure 1 - Number of point counts with Barn-owls (A) and proportion of point counts with Barn-owls (B) per district in the systematic census. Please refer to the Supporting Information for the inset map (Figure S1) and district location (Figure S2). Darker shades of blue represent higher values.

Figura 1 - Número de pontos de escuta com Coruja-das-torres (A) e proporção de pontos de escuta com Coruja-das-torres (B) por distrito no censo sistemático. Consulte a Informação Suplementar para visualizar o enquadramento geográfico (Figura S1) e a localização dos distritos (Figura S2). Tons de azul mais escuro representam valores mais elevados.

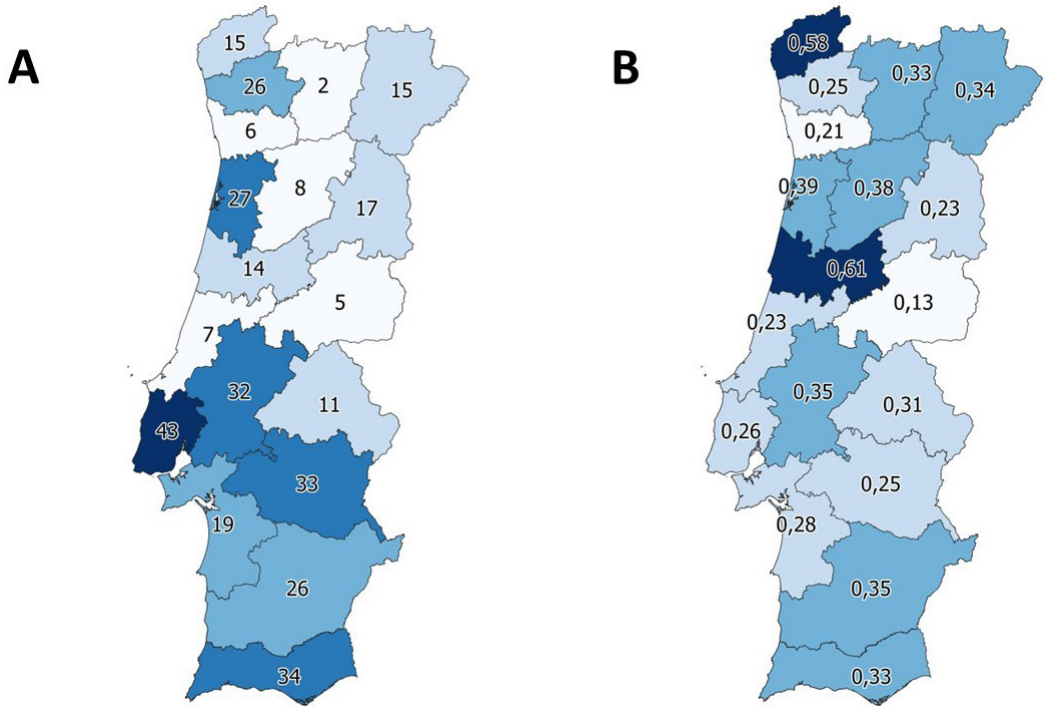

Table 1 - Results of the systematic census, using the methodology of point counts with Barn-owl playbacks.

Tabela 1 - Resultados do censo sistemático, utilizando a metodologia de pontos de escuta com reprodução de vocalizações de Coruja-das-torres.

District	Area (km²)	District Coordinators	Number of participants	Number of point counts	Number of point counts with Barn-owls	Proportion of points with Barn-owls
Aveiro	2 808	Daniel Santos	30	69	27	0.39
Beja	10 263	Hugo Lousa, Alexandre Leitão	11	74	26	0.35
Braga	2 673	Vasco Flores Cruz	24	102	26	0.25
Bragança	6 608	Carlos Santos	16	44	15	0.34
Castelo Branco	6 675	Ana Botelho, Tiago Carvalho	6	40	5	0.13
Coimbra	3 947	Rui Machado	8	23	14	0.61
Évora	7 393	Jorge Safara, Rui Lourenço	25	131	33	0.25
Faro	4 960	Guillaume Réthoré, Ricardo Correia	20	104	34	0.33
Guarda	5 518	Eduardo Realinho	27	73	17	0.23
Leiria	3 515	Hélder Cardoso	9	30	7	0.23
Lisboa	2 761	João Falé, Ricardo Tomé	48	163	43	0.26
Portalegre	6 065	Filipe Canário	5	35	11	0.31
Porto	2 395	GTAN	5	29	6	0.21
Santarém	6 747	Paulo Alves, Inês Roque	27	92	32	0.35
Setúbal	5 064	Mário Estevens, Daniel Raposo	15	69	19	0.28
Viana do Castelo	2 255	Sandra Fernandes	8	26	15	0.58
Vila Real	4 328	Paulo Travassos	1	6	2	0.33
Viseu	5 007	Nuno Campos	3	21	8	0.38
TOTAL			**268**	**1131**	**340**	**0.30**

Figure 2 - Number of point counts with Barn-owls (A) and proportion of point counts with Barn-owls (B) per district in the systematic census. Please refer to the Supporting Information for the inset map (Figure S1) and district location (Figure S2). Darker shades of blue represent higher values.

Figura 2 - Número de pontos de escuta com Coruja-das-torres (A) e proporção de pontos de escuta com Coruja-das-torres (B) por distrito no censo sistemático. Consulte a Informação Suplementar para visualizar o enquadramento geográfico (Figura S1) e a localização dos distritos (Figura S2). Tons de azul mais escuro representam valores mais elevados.

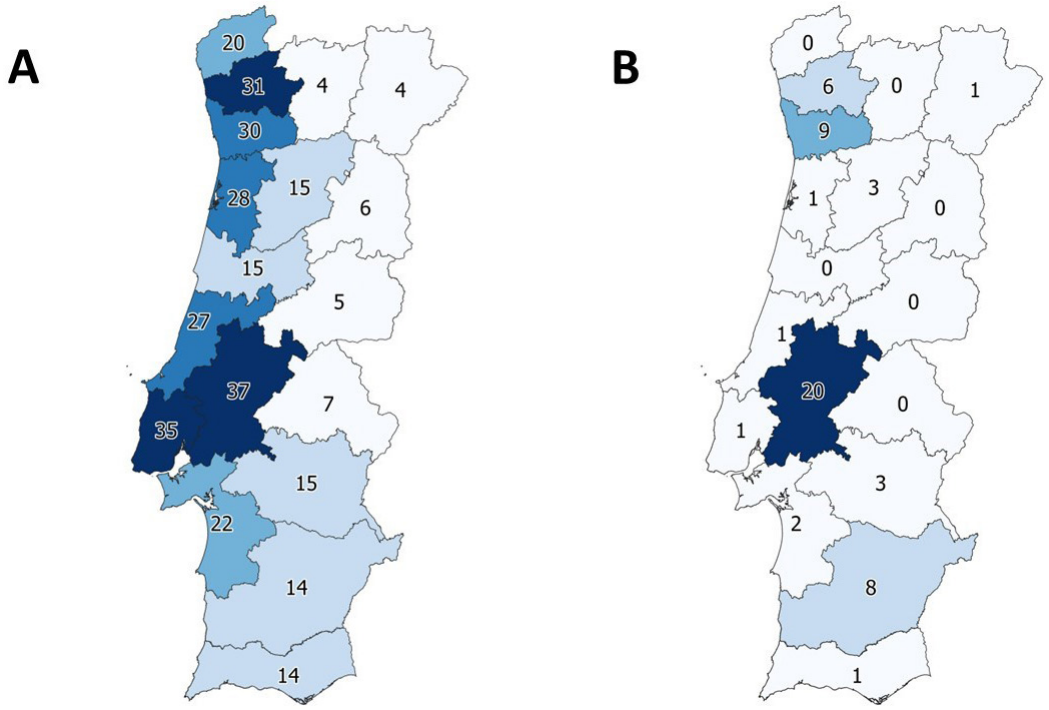

Table 1 - Results of the non-systematic census, using the methodologies of online surveys and non-systematic passive listening point counts.

Tabela 1 - Resultados do censo não sistemático, utilizando as metodologias de inquérito online e de pontos de escuta passiva não sistemáticos.

District or Autonomous region	Online survey		Passive listening point counts	
	Number of surveys	*Number of surveys with Barn-owls*	*Number of point counts*	*Number of point counts with Barn-owls*
Aveiro	30	28	1	1
Beja	16	14	9	8
Braga	33	31	17	6
Bragança	5	4	1	1
Castelo Branco	6	5	0	0
Coimbra	16	15	0	0

District or Autonomous region	Online survey		Passive listening point counts	
	Number of surveys	*Number of surveys with Barn-owls*	*Number of point counts*	*Number of point counts with Barn-owls*
Évora	23	15	8	3
Faro	21	14	1	1
Guarda	10	6	0	0
Leiria	28	27	4	1
Lisboa	42	35	2	1
Madeira	16	15	6	5
Portalegre	8	7	10	0
Porto	32	30	12	9
Santarém	48	37	61	20
Setúbal	34	22	14	2
Viana do Castelo	26	20	0	0
Vila Real	5	4	0	0
Viseu	15	15	4	3
TOTAL	**414**	**344**	**150**	**61**

Combining the information of 10x10 km squares with Barn-owl presence obtained from the systematic (211 in mainland) and non-systematic (218 in mainland, nine in Madeira) approaches, along with records from PortugalAves/eBird (205 in mainland, six in Madeira), it was possible to determine the presence of Barn-owls in a total of 399 squares in mainland Portugal and 11 in the Madeira archipelago (Figure 3). The combination of the systematic and non-systematic approaches resulted in 348 squares with Barn-owl presence, which means that the non-systematic approach contributed 137 new squares (34% of the total). In turn, the combination of the systematic approach with PortugalAves/eBird resulted in 292 squares with Barn-owl presence, indicating that eBird contributed an additional 81 squares (20% of the total). A total of 454 squares (45%) did not have any systematic or non-systematic visit (with or without Barn-owl presence) and no eBird record of Barn-owl presence as well, which could be considered as the non-sampled area. In 2023, the Barn-owl was distributed throughout mainland Portugal, in line with the information from previous years (Figure 4). In the Madeira archipelago, the Barn-owl was present on the islands of Madeira and Porto Santo (Figure 5).

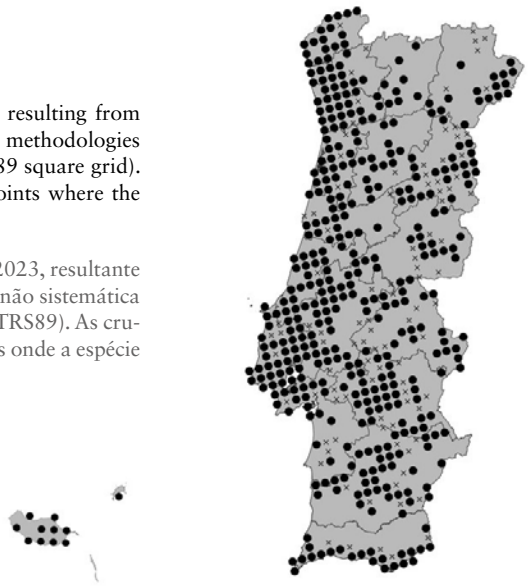

Figure 3 - Distribution of the Barn-owl in Portugal in 2023 resulting from combining the results of the systematic and non-systematic methodologies and the information in PortugalAves/eBird (10x10 km ETRS89 square grid). Cross symbols represent squares with systematic listening points where the species was not detected.

Figura 3 - Distribuição da Coruja-das-torres em Portugal em 2023, resultante da combinação dos resultados das metodologias sistemática e não sistemática e dos registos no PortugalAves/eBird (quadrícula 10x10 km ETRS89). As cruzes representam quadrículas com pontos de escuta sistemáticos onde a espécie não foi detetada.

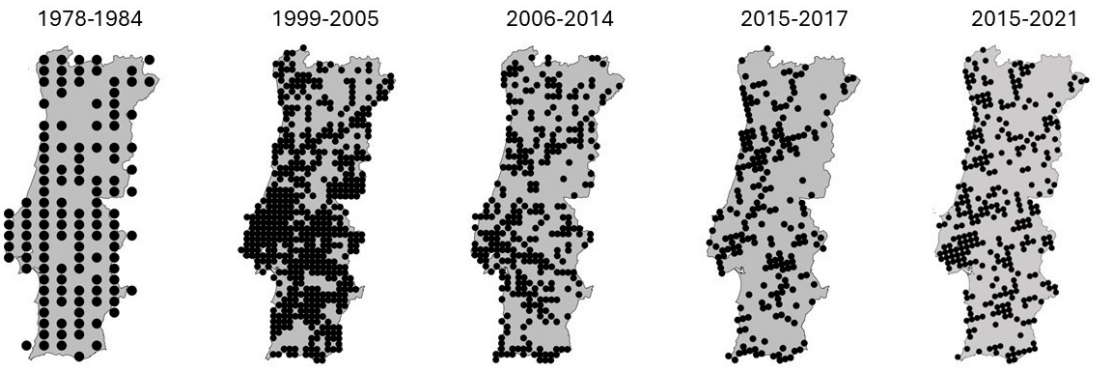

Figure 4 - Distribution of the Barn-owl in mainland Portugal over five periods: 1978-1984 (Rufino 1989; 20x32 km military maps rectangles grid), 1999-2005 (Equipa Atlas 2008 10x10 km UTM squares grid), 2006-2014 and 2015-2017 (10x10 km UTM squares grid, 10x10 km ETRS89 squares grid respectively; Lourenço et al. 2021), and 2015-2021 (10x10 km ETRS89 squares grid; Equipa Atlas 2023). Different circle sizes represent different sampling units.

Figura 4 - Distribuição da Coruja-das-torres em Portugal continental ao longo de cinco períodos: 1978-1984 (carta militar 20x32 km; Rufino 1989), 1999-2005 (quadrícula 10x10 UTM; Equipa Atlas 2008), 2006-2014 e 2015-2017 (quadrícula 10x10 UTM e quadrícula 10x10 ETRS89, respetivamente; Lourenço et al. 2021), e 2015-2021 (quadrícula 10x10 ETRS89; Equipa Atlas 2023). Círculos de tamanho diferente representam unidades de amostragem distintas.

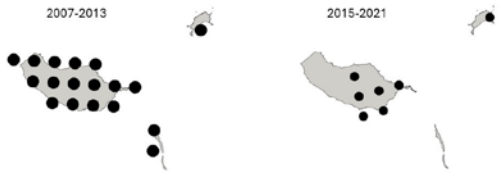

Figure 5 - Distribution of the Barn-owl in the Madeira archipelago in the periods 2007-2013 (Equipa Atlas 2013; Lourenço et al. 2015) and 2015-2021 (Equipa Atlas 2023).

Figura 5 - Distribuição da Coruja-das-torres no arquipélago da Madeira nos períodos de 2007-2013 (Equipa Atlas 2013; Lourenço et al. 2015) e 2015-2021 (Equipa Atlas 2023).

The population estimate for the Barn-owl in 2023, based on the combination of data from the national census and PortugalAves/eBird, ranges between 800 and 5 000 breeding pairs (mainland Portugal and Madeira). The minimum number of breeding pairs in mainland Portugal was estimated at 812, while the maximum estimate for the mainland was 4 844. The estimate limits were adjusted to the lower hundred and higher thousand, to provide a more conservative range and to include the breeding population in Madeira.

Discussion

In mainland Portugal, discontinuities in Barn-owl distribution found in this study often coincide with areas of lower human population density and inaccessibility, such as the mountains of the northern interior and the Algarve, and some areas of the interior of Alentejo. Therefore, these discontinuities may be partly due to information gaps in these regions. Nevertheless, the local disappearance of the species within its range is consistent with its known sensitivity to small-scale habitat changes, which have been associated with population declines (Taylor 1994, Martínez & Zuberogoitia 2004). The local decline of Barn-owl populations may result from an intricate combination of factors acting selectively at different spatial scales, such as the loss of foraging areas mostly due to agriculture intensification, the loss of roosting and nesting sites, and increased mortality due to the expansion of road networks and increased traffic intensity (Martínez & Zuberogoitia 2004, Grilo et al. 2012). All these factors are known to have affected local Barn-owl populations in Portugal, to some extent. For example, Barn-owls have previously been detected in the mountains of south-western Algarve, before the conversion of traditional agricultural areas into forest plantations, or land abandonment and subsequent transformation into scrublands, which made these areas less suitable for Barn-owls (Lourenço et al. 2015, Lourenço et al. 2021; Figure 4). In the Tagus valley, there are records of a 30% loss of the sites traditionally used by Barn-owls over a 5-year period in the early 2000s (I. Roque unpublished data), which may reflect a large increase in the degradation of man-made structures used by the species to nest and/or roost. Regarding road mortality, Barn-owl estimates are among the highest for raptors, ranging between 0.35 and 0.49 owls/km/year in southern Portugal (Silva et al. 2008; Gomes et al. 2009; Grilo et al. 2014), and reaching up to 1.13 owls/km locally (Roque et al. 2021). Additionally, the rapid expansion of intensive monocultures, particularly olive production in Alentejo, is expected to negatively affect species occupying the former open farmland areas (Morgado et al. 2020). On the other hand, along the central and northern coast of the country, Barn-owl distribution appears to be more continuous than in previous population estimates, even in heavily forested districts, possibly linked to favourable patches of micro-habitat, such as extensive agriculture near human settlements.

In the Madeira archipelago, there have been no volunteers regularly collaborating in systematic owl censuses. However, records from contributors to PortugalAves/eBird represented two (18%) of the 11 10x10 km squares reported in the archipelago in this census. The Barn-owl is the only owl species that breeds regularly on these islands. The best up-to-date available information for the endemic subspecies (T. a. schmitzi), which has not been surveyed since 2013 (Lourenço et al. 2015), fully relies on non-systematic records. The results of the present census are consistent with previous studies that described the subspecies as very common in low altitudes near Funchal, while also occupying the walls of ravines located inland up to 600 m above sea level, but avoiding the dense stands of laurel forest above that altitude (Silverio et al. 2001). Although our

non-systematic census registered the presence of the Barn-owl on the islands of Madeira and Porto Santo, in the previous systematic census the species was also detected on Deserta Grande (Equipa Atlas 2013), a small (~1 000 ha) uninhabited island, from which presence data would largely depend on the use of systematic methods. The same census indicated a negative fluctuation in the Barn-owl population in Madeira, with the species detected in 34 2x2 km squares in 2007, and in 24 squares in 2013 (Equipa Atlas 2013). For these reasons, future editions of the National Barn-owl census should also include the application of systematic methods in the Madeira archipelago.

The upper limit of the Portuguese Barn-owl population estimate in 2023 (800 – 5 000 breeding pairs) fell below the lower limit estimated for the 2005–2014 period (5 700 – 8 100 breeding pairs, Lourenço et al. 2015), below the estimated limits in 2002 (2 000 – 6 000 breeding pairs, BirdLife International 2004), and was closer to the lower limits of the first national estimate (1 000 – 10 000 breeding pairs in 1978-1984, Rufino 1989). This seems to reflect the decreasing short-term population trend estimates for the Iberian Peninsula and Europe (EIONET 2023, GTAN-SPEA 2023) and it may also indicate a decreasing long-term population trend. It should also be noted that the methods used to calculate the intervals have varied across estimates and, for this reason, should be compared with caution. For example, the method used in 2015 produced the narrowest interval and was based on distribution data over a longer period, whereas the 2023 estimate relied on distribution data from a single year and had a 75% broader interval. Nevertheless, our census detected the Barn-owl in 26% more squares than the latest Portuguese Breeding Bird Atlas (Equipa Atlas 2023), which was based on seven years of sampling and had 32% more coverage. This suggests that using mixed methods (i.e., systematic and non-systematic) targeting only the Barn-owl was more effective at collecting presence data in a single year than systematic methods targeting multiple species over several years. Therefore, although our census detected the Barn-owl more widely, it produced the lowest population estimate, which is consistent with the observed decrease in the Barn-owl population.

Our efforts to adapt and communicate the census to new volunteers delivered 34% more data in terms of distribution squares than if it had relied only on trained volunteers. Additionally, opening the census to the unexperienced public allowed to (1) collect data in the Madeira archipelago, (2) involve more than 1 000 people in a bird census, most of which would not have participated with a systematic methodology alone, and (3) engage many volunteers (56%) for the first time in citizen science. As guidance for future organization of non-systematic Barn-owl censuses, we highlight that the news media coverage and outreach through social media via third parties (organisations not directly involved in coordinating the census) were the most effective way of engaging the general public. On the other hand, direct contact efforts with specific audiences (schools, scout groups and non-governmental organizations) resulted only in 16% of the submitted records. Nevertheless, we should not undervalue the potential of involving these audiences in recruitment and environmental education in their wider communities. The district with higher school participation (Santarém) was also the one where more data was submitted in the non-systematic census. In the district with the second highest number of records submitted in the non-systematic point counts (Braga) a non-governmental organization (Rio Neiva), carried out field trips for their members, involving between 5 and 28 people per night.

This census established the baseline for future targeted national census of the Barn-owl, enabling estimate reliable long-term population trends. Both census methods used had advantages, and we suggest they should be maintained and adapted in future editions. On the one hand, systematic censuses ensure

(1) a lower probability of observer error, (2) a controlled distribution of sampling effort (e.g., allocating volunteers or professionals to unpopulated areas, as in the previous Madeira census (Equipa Atlas 2013), provided there is funding and/or institutional support), and (3) quantification of the sampling effort, which allows for the calculation of detection frequency and its comparability along years to produce population trend estimates. On the other hand, non-systematic censuses have the advantages of (1) covering a wider geographical area, thus helping to fill gaps and having a more accurate knowledge of the species distribution (regardless of specific financial support, but we should emphasise that our census was supported by several institutions that contributed their staff time), and (2) raising awareness for bird conservation among a wider public, which has the potential to recruit new volunteers for bird censuses.

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