Universidade de Évora – Escola de Ciências e Tecnologia

Mestrado em Biologia da Conservação

Dissertação

Evaluation of habitat preferences for the establishment of reed passerine territories

Daniela Rocha Jesus

Orientador(es) | Pedro Miguel Filipe Pereira

Évora 2022

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Avaliação das preferências de habitat para o estabelecimento de territórios de passeriformes de caniço

Resumo

As zonas húmidas palustres na região mediterrânica são dos ecossistemas mais ameaçados na Europa. Estes habitats denominam-se caniçais dada a presença abundante da espécie *Phragmites australis*. Algumas espécies de passeriformes dependem das zonas húmidas para realizar parte ou a totalidade do seu ciclo de vida anual, como tal são bons bioindicadores para compreender o estado de conservação destes habitats.

Este estudo decorreu em duas zonas húmidas do centro-oeste de Portugal durante a época de reprodução de passeriformes de caniço. Com o objetivo de avaliar as preferências de habitat destas espécies, foram recolhidas variáveis ambientais relativas à dinâmica e heterogeneidade de habitat. Os resultados permitiram compreender a importância da altura do caniço e a presença de vegetação lenhosa para as espécies de passeriformes de caniço. Este estudo destaca a importância destas características quando se tomam medidas para promover a utilização sustentável e a conservação de zonas húmidas, evitando a perda de habitats de grande importância ecológica.

Palavras-chave: região mediterrânica; zonas húmidas palustres; passeriformes de caniço; caniçal

Evaluation of habitat preferences for the establishment of reed passerine territories

Abstract

The palustrine wetlands in the Mediterranean region are among the most threatened ecosystems in Europe. These habitats are called reedbeds and are dominated by *Phragmites australis*. Some passerines species depend on wetlands at least for part of their annual life cycle, as such they are good bioindicators to understand the conservation status of these habitats.

This study took place in two wetlands in central-western Portugal during the breeding season of reed passerines. In order to assess the habitat preferences of these species, environmental variables relating to the dynamics and heterogeneity habitats were collected. The results reveled the importance of reed height and presence of woody vegetation for reed passerine species. This study highlights the relevance of these habitat characteristics when taking measures to promote the sustainable use and conservation of wetlands, avoiding the loss of such ecologically important habitats.

Keywords: Mediterranean region; palustrine wetlands; reed passerines; reedbed

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1. Introduction

Wetlands are complex and dynamic systems of great ecological importance. They regulate the water cycle, protect against flooding, maintain water quality control pollution and are highly productive (Ramsar Convention Secretariat, 2016). In addition, the microclimate conditions present of these areas provide unique habitats for a wide diversity of species, containing over 40% of the world's species (Chawaka et al., 2017; Janse et al., 2019).

There are several definitions for wetlands. The most widely adopted is the definition of the Ramsar Convention - a Convention that promotes the conservation and responsible use of wetlands (Ramsar Convention on Wetlands, 2018). Thus, wetlands can be defined as areas of marsh, marshland, peatland, permanent or temporary water, with stagnant or flowing, fresh, brackish or salt, including marine water in which depth at low tide does not exceed six meters (Ramsar Convention Secretariat, 2016). Among the five main categories currently recognized as wetlands (marine, estuarine, lacustrine, riparian and palustrine) by the Ramsar Convention, palustrine freshwater wetland ecosystems which are among the most threatened in Europe, are of particular importance (Janssen et al., 2016).

Palustrine wetlands are generally located in low-lying marshlands, such as swamps and floodplains (Kingsford et al., 2016). They can be seasonally or permanently flooded, and are generally shallow (Ramsar Convention Secretariat, 2016). This dynamic in the water level can be beneficial for local species (Alambiaga et al., 2021), favoring the development of a characteristic aquatic and emergent vegetation, such as *Carex* sp., *Juncus* sp., *Typha* sp., *Phragmites australis* and woody plants (*Salix atrocinerea*, *Quercus faginea*, *Rubus* sp.) (Benassi et al., 2009). The presence of emergent vegetation on the edges and the dispersed woody vegetation (arboreal or shrubby) present in this type of wetland gives these areas a heterogeneity of microhabitats that exert strong effects on the structure and functioning of these ecosystems, thus allowing them to support a rich and diverse fauna (Benassi et al., 2009; Riegert, 2021). These ecosystems are called reed beds, due to the abundant presence of the species *Phragmites australis*, commonly known as reed (Valkama et al., 2008). Reeds grow densely during spring attenuating the actions of wind and radiation and promoting ideal conditions for the development of insects, a source of food for passerines that, use this vegetation to build their nests (Paracuellos, 2008; Valkama et al., 2008; Meyer et al., 2010; Darolová et al., 2014; Trnka et al., 2014).

Reed passerine species depend on wetlands for part or all of their annual life cycle, including resident or all types of migratory species, including species that visit such areas for breeding, wintering or passing between breeding and wintering grounds (Martínez-Vilalta et al., 2002; Chawaka et al., 2017; Perennou et al., 2020). Currently, several species of reed passerines are suffering population declines, such as the Great Reed Warbler (*Acrocephalus arundinaceus*), with a 37% decline in Europe in the last few years (Chawaka et al., 2017; Pan-European Common Bird Monnitoring Scheme, 2021), as well as Common Reed Warbler (*Acrocephalus scirpaceus*) and Savi's Warbler (*Locustella luscinioides*) that are classified as "Near Threatened" and "Vulnerable", respectively, according to the Red Book of Vertebrates of Portugal (LVVP) (Cabral et al., 2005).

In Europe, for thousands of years, the wetlands around the Mediterranean basin were essential for the development of the major civilizations built there, which depended on these sites for essential resources such as water, food, and materials (Papayannis & Sorotou, 2007; Kingsford et al., 2016; Geijzendorffer et al., 2019). According to Papayannis & Salathé (1998), Mediterranean wetlands have specific conditions that must be considered, as they are highly diverse in fauna and flora, given the climatic variability and also the continued dependence of humans on these areas.

In recent decades, wetlands areas have been declining and disappearing on a large scale and are under severe threat worldwide (Robledano et al., 2010; Kingsford et al., 2016; Riegert, 2021). The main threats for wetland bird species are climate change, increase in invasive exotic species and the intensification of anthropogenic activities such as the conversion of natural habitats, pollution, changes in the natural functioning of watercourses and ponds, and intensive hunting and fishing (Chawaka et al., 2017; Jiménez et al., 2018; Prasad et al., 2021). Wetland conservation is gaining attention from academics and policymakers, however there is still a visible lack of monitoring of their biodiversity and the ecological changes to which they are subjected (Papayannis & Sorotou, 2007; Geijzendorffer et al., 2019; Alambiaga et al., 2021). In Portugal few studies exist on reed passerines in this type of wetlands, with only a few studies in larger areas, such as the Sado estuary by Teixeira (1980), the Santo André lagoon by Catry et al., (2004) or the Ria de Aveiro (Neto, 2003; Neto & Gosler, 2005). But the importance of wetlands is not weighted according to their size, so smaller areas can also represent great conservation importance and are more vulnerable to environmental changes (Perennou et al., 2020).

Ecology studies on the reed passerine community are crucial to understand the conservation status of wetlands, as birds are an excellent bioindicator, given their fast response to environmental changes (Robledano et al., 2010; Chawaka et al., 2017; Prasad et al., 2021). Furthermore, understanding which environmental features these species select could be an asset for the conservation of their populations as well as for their habitats (Moreno-mateos et al., 2009).

This study aimed to evaluate the influence two factors potentially affecting the conservation of Mediterranean wetlands using bird community as bioindicator, I analyzed the effect of habitat characteristics on the establishment of reed passerine territories, namely the most frequent breeding species and their total species richness. The research was focused on the effects of water presence and dry reed height as indicators of habitat dynamism and the presence of woody vegetation as indicator of habitat heterogeneity.

2. Material and Methods

2.1. Study area

This study was carried out in two small wetlands with abundant reed, located in central-western Portugal, in Leiria district (Figure 1): Paul de Tornada Natural Reserve (39°44'N, -9°13'W) and Poças do Vau (39°37'N, -9°21'W). In 2021, the western region recorded an average temperature of 9.81ºC and precipitation of 373.3 mm in winter (IPMA, 2021b) and 14.6ºC and 130.6 mm in spring (IPMA, 2021c).

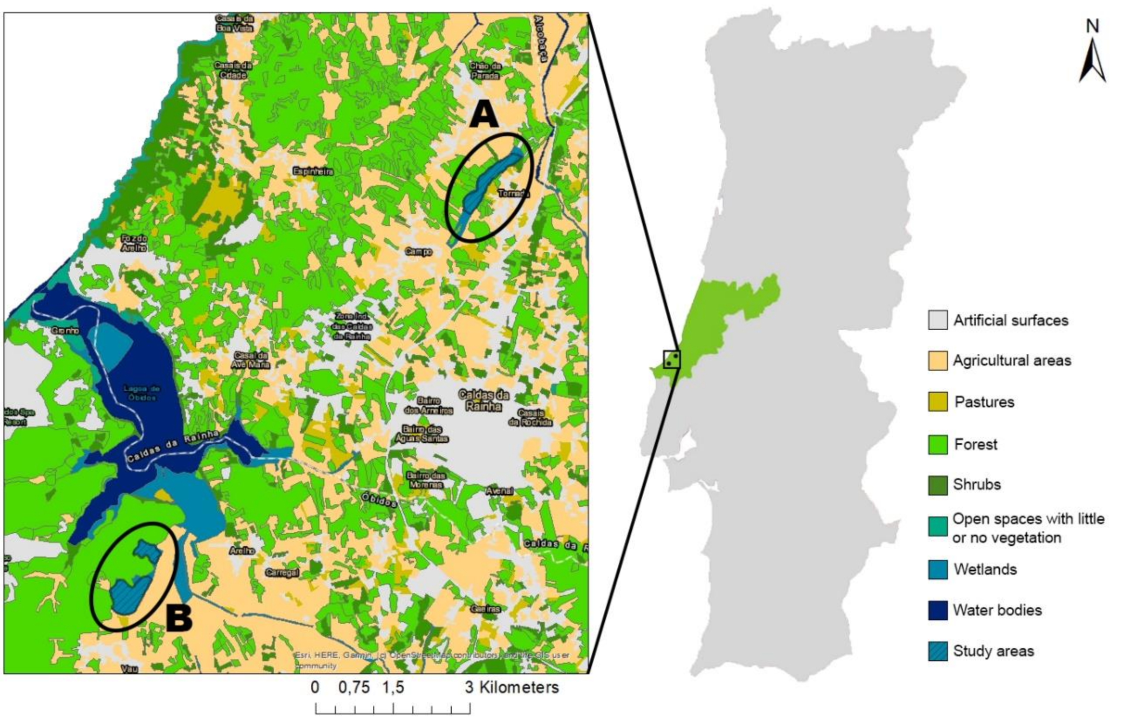

Figure 1: Location of the study area in central-western Portugal, in Leiria district. (A) Paul de Tornada Natural Reserve; (B) Poças do Vau.

Study areas are geographically close, being approximately 10 km apart in a straight line. Located in Ibero-Atlantic Mediterranean province, the soils of this region are very siliceous. This characteristic promotes the development of vegetation more resistant to drought (Costa et al., 1998), which can be found in both wetlands. However, it should be noted that both wetlands differ in their hydric regime and conservation conditions:

Paul de Tornada, located in the village of Tornada, Caldas da Rainha, was classified as a Ramsar site in 2001 by the Convention on Wetlands of International Importance. In 2009 it was designated, under the national legislation, as the Paul de Tornada Local Nature Reserve - RNLPT (CM Caldas da Rainha, 2009). The Paul covers approximately a total of 45 ha, of which 25 ha are permanently flooded. In this area we can find three drainage ditches: the Middle ditch, which crosses the central area of the Paul, the Palhagueira ditch, to the west and the Guarda-Mato ditch, to the east that drain from south to north, flowing into the Tornada river. The Paul is one of the few existing freshwater palustrine areas in the region, having essential features for nesting, feeding and shelter of several bird species, including its natural vegetation, with major conservation value (Diário da Républica, 2009; ICNF, n.d)

Poças do Vau (or depressions of Vau) are located upstream of Óbidos Lagoon, in the village of Vau, and were formed with silting up of a shallow flooded region in a branch lagoon (Azerêdo et al., 2006). Despite its remarkable surrounding landscape typical characteristics of a palustrine wetland, the Poças do Vau have not been granted the status of protected area. The Poças do Vau have typical Mediterranean seasonal water dynamism, with an average level of one meter during the winter and partial drought during the summer. A rectilinear ditch is present in the larger depression (poça grande) along its entire length, and this water line has undergone intense artificialization processes in order to allow drainage to the entire surrounding region, namely to agricultural lands and eucalyptus plantations (Azerêdo et al., 2006).

2.2. Target species

The Atlas of Breeding Birds in Portugal (ICNB, 2008) was used to compile a list of reed passerine species of potential occurrence in the study areas. The communities of passerine birds present in these areas have some common characteristics (Báldi & Kisbenedek, 1999), namely their body size; feeding - they are all insectivorous species; plumage color - in shades of brown (Figure 2 to 6); preference for lower altitudes and their breeding season occur between April and July (Kennerley & Pearson, 2010; Keller et al., 2020).

Common Reed Warbler (*Acrocephalus scirpaceus*, Kermann, 1804)

Figure 2: *Acrocephalus scirpaceus* illustration by Daniela Jesus

- Length 12–14 cm; wing 60–74 mm (Kennerley & Pearson, 2010);
- A Long-distance migrant (Kennerley & Pearson, 2010); Occurs almost everywhere in Europe. In Portugal it's present essentially on the coast (ICNB, 2008);
- Builds nests typically placed 0.5–1.5 m above the water, among old reed (3 to 4 reeds) stems or a mixture of old and new (Neto, 2003; Kennerley & Pearson, 2010);
- It typically occurs below 1,400 m (Kennerley & Pearson, 2010);
- The highly distinctive song consists of a slow rhythmic series of softly grating and squeaky notes repeated two or three times: '*chup-chup-chir-chir-churric-churric-churric- whit-whit-whit churruc-churruc-*' (Kennerley & Pearson, 2010).

Great Reed Warbler (*Acrocephalus arundinaceus*, Linnaeus, 1758)

Figure 3: *Acrocephalus arundinaceus* illustration by Tiago Oliveira.

- Length 18–20 cm; wing 89–104 mm (Kennerley & Pearson, 2010);
- A long-distance migrant. Occurs in from S and SW Europe across most parts of Europe to N Central Asia (Keller et al., 2020);
- Is a widespread reedbed specialist (Van der Hut, 1986) Builds its nests usually in *phragmites* reeds, 50 cm above the water (Kennerley & Pearson, 2010);
- In Europe, it breeds mainly in lowlands, although it occurs up to 650 m in Switzerland (Kennerley & Pearson, 2010);
- The full song is loud and raucous, a steady rhythmic sequence of notes, each repeated about three times: *'karra-karra-karra gurk-gurk-gurk chirr-chirr, karra-karra, keet-keet-keet…*' (Kennerley & Pearson, 2010).

Cetti's Warbler (*Cettia cetti*, Temminck, 1820)

Figure 4: *Cettia cetti* illustration by Tiago Oliveira.

- Length 13–15 cm; wing, male 58–72 mm, female 52–66 mm (Kennerley & Pearson, 2010);

- In Europe, it's mainly present in the Mediterranean region, but also occurs across the SW Atlantic region and reaches the Caucasus, S Russia and Kazakhstan in the E (Keller et al., 2020). In Portugal, occurs practically throughout the continental territory (ICNB, 2008);

- Preference low altitudes, although it can be found up to 1400 meters (Keller et al., 2020);

- The song commences with an introductory explosive 'tchi' or 'chuit' that is followed immediately by a rapid series of 'chuee': '*chuit chuee-chuee-chuee-chuee-chuee'* (Kennerley & Pearson, 2010).

Zitting Cisticola (*Cisticola juncidis*, Rafinesque, 1810)

Figure 5: *Cisticola juncidis* illustration by Daniela Jesus

- Length 10 cm (Bruun et al., 2002);

- Its distribution in Europe extends over the Peninsula, southern France, and Italy. In Portugal its distribution is widespread, except in colder areas such as Trás-os-Montes and north-central regions (Keller et al., 2020);

- Builds its nests mostly in vegetation such as rushes, grasses and low shrubs, found on the verges of agricultural land (Fenech, 2012); The young are fed on a variety of insects and arachnids (Fenech, 2012);

- Called name 'zitting' because of its characteristic sound that while marking its territory, repeats the sound "zip-zip-zip-zip" during the zigzag flight (McGregor et al., 1990).

Savi's Warbler (*Locustella luscinioides*, Savi 1824)

Figure 6: *Locustela luscinioides* illustration by Daniela Jesus

- Length 13–14 cm; wing 66–77 mm (Kennerley & Pearson, 2010);

- A long-distance migrant. Breed in wetlands and reedbeds from E Europe to C Asia winters in N tropical Africa (Kennerley & Pearson, 2010; Keller et al., 2020);

- Builds nests under dense vegetation (Neto & Gosler, 2005); Picks food from low stems, or from the mud or water surface (Kennerley & Pearson, 2010);

- Preference low altitudes it is frequently found in mountain wetlands up to 1,800 m (Gavrilov & Gavrilov, 2005);

- Its song which reminds one of an insect "*surrrrr*" (Bruun *et al.,* 2002).

2.3. Data collection

2.3.1. Bird sampling

Bird sampling was performed by developing a territory mapping method (Bibby et al., 2000) during six periodic visits (every 15 days) to each study area, using a 50x50 meter grid (n=106). The frequency of each target species per square was measured between April and June 2021, corresponding to their nesting season. The grid (Figure 7) was built using the ArcMap program, a component of the ArcGIS software version 10.6 (ESRI, 2018), considering the average song range measurements of the target species, as suggested by Báldi & Kisbenedek, (1999). Consequently, a total of 30 squares were considered for Paul de Tornada (Paul) and 76 squares for Poças do Vau (Poças).

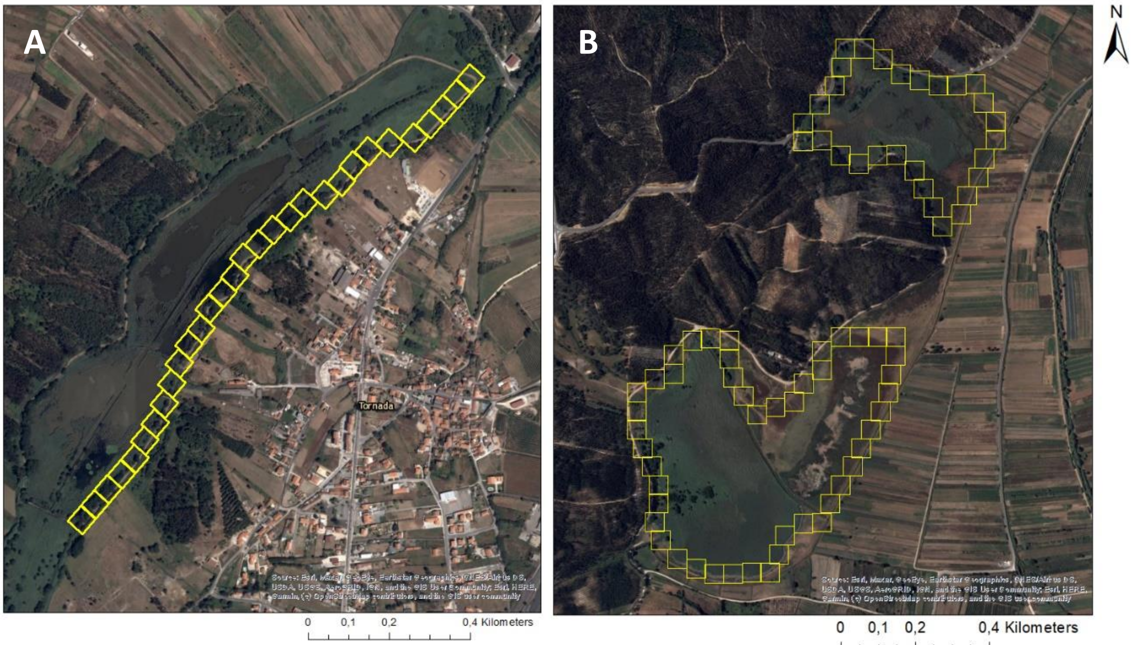

Figure 7: Study areas with the 50x50 meter grid (A) Paul de Tornada Natural Reserve; (B) Poças do Vau. Executed in the ArcGIS software.

Observations were made during rainless days with minimal wind, at a constant speed (approx. 1.5 km/h), allowing the day, time, and coordinates of each point to be recorded. Bird sampling always took place between 7:30 and 10:30 a.m., when the territorial individuals are more active vocally (Bibby et al., 2000), in clockwise and counterclockwise directions (in Poças), and in a south-north and north-south direction (in Paul). Due to the very dense structure of the reed bed, visual detection was difficult. Therefore, the observation and identification of birds were hence carried out mainly through the singing of males.

In both study areas, data were only collected at the wetland edges due to 1) logistic constrains to survey the entire area and 2) target species preferences for the edges which tend to have higher availability and denser reed cover than at the wetland center according to Báldi & Kisbenedek, (1999) and Báldi, (2004).

2.3.2. Environmental variables

Information was collected for the creation of three environmental variables with ecological significance for the establishment of the territories of the passerine species targeted in this study at the 50x50 meter grid level: 1) water frequency (being 0, never present and 6, always present), 2) dry reed height (in meters, at the water surface), and 3) presence of woody plant species.

In wetlands, water is an essential component for the development of the surrounding vegetation as well as for the fauna and flora that inhabit it (Battisti et al., 2006; Perennou et al., 2020), as is the case of the specie *Phragmites australis*, whose presence is a determining factor for the nesting of the target species (Báldi & Kisbenedek, 1999). Furthermore, the assessment of the landscape is an essential requirement for the study of these species (Batáry et al., 2004). Habitat features were recorded by square at each visit and along the transects to assess the dynamics of the study areas, namely the presence/absence of water and height of dry reed to the water surface, considering the approximate height of the observer (DJ - 1.60 meters). To characterize habitat heterogeneity, I evaluated the presence of woody plants (essentially *Salix atrocinerea*, *Quercus faginea* and *Rubus* sp.), using the geographic information system, ArcMap, a component of the ArcGIS software.

2.4. Data analysis

The collinearity of the environmental variables was analyzed using Spearman correlations. All combinations of variables showed a correlation of lessthan [0.7] (r_s < [0.7]) so the three variables were retained for the following statistical procedures. To analyze the effects of environmental conditions on the establishment of reed passerines, generalized linear mixed models (GLMMs) were developed using R software, version 4.0.5 (R Core Team, 2013).

Species richness and frequency of each species per square were considered as response variables and water frequency, dry reed height (reed) and presence of woody plants as explanatory variables (Table 1). For each response variable, four models with Poisson distribution (because it refers to counts) were computed: one for each environmental variable and one null model (model with no variables), in the form of hypothesis tests. The study area was used as a random factor (with two levels) as I only sampled two sites from a wider universe of wetlands in western Portugal. Nevertheless, the two study areas are quite representative of such national region and allowed to obtain data with a great spatial heterogeneity and variable water levels along a season.

Table 1: Mean and standard deviation of the environmental variables analyzed in the study: water frequency per visit; dry reed height (in meters) and presence of woody plants throughout the visits in each study area (n = number of squares).

	water	reed	woody plants
Paul (n=30)	6.0 ± 0	2.1 ± 1.03	0.8 ± 0.38
Poças (n=76)	3.4 ± 2.06	1.5 ± 0.91	0.4 ± 0.49
Total (n=106)	4.2 ± 2.09	1.7 ± 0.98	0.5 ± 0.5

Models were ranked according their Akaike information criteriom, corrected for small samples (AICc). The AICc difference (ΔAICc) and the Akaike weight were also determined (Burnham & Anderson, 2002). The best models were selected when ΔAICc < 2 (Liddle et al., 2009). Model-averaged coefficients of all explanatory variables were determined. The model results were validated using Q-Q plots (Quantile-Quantile plots). R packages used in the analyses were 'lme4' and 'MuMIn', function ''model.avg'' (Burnham & Anderson, 2002).

The analyses were only performed on the most frequent species in the study area to avoid spurious results duo to eventual failures in their detectability because rarer species could sing less which compromise their detectability (Morelli et al., 2022). Moreover, focusing the study on most frequent species, problems in the analyzes resulting from an excess of absences (“zeros”) are avoided (Zuur et al., 2009).

3. Results

Four of the target species were observed during the bird sampling, with an average richness of 1.91 ± 1.06 per square (Table 2). The species observed were present in both study areas except for *Cisticola juncidis*, which was only recorded in Poças. The most frequent species in the study area were *Acrocephalus scirpaceus* and *Cettia cetti* (Table 2 and Figure 8). The two other species had a major proportion of absences than presences (Figure 8), therefore the effects of the influence of dynamics and heterogeneity were evaluated in only in the two previous species (*A. scirpaceus* and *C. cetti*).

Table 2: Mean and standard deviation of observed target species frequency and species richness.

	A. scirpaceus	*C. cetti*	*C. juncidis*	*L. luscinioides*	Species richness
Paul (n=30)	2.47 ± 1.20	1.6 ± 1.19	0	0.63 ± 0.76	2.27 ± 0.74
Poças (n=76)	1.47 ± 1.49	0.87 ± 1.02	0.51 ± 0.96	0.42 ± 0.79	1.76 ± 1.14
Total (n=106)	1.75 ± 1.48	1.08 ± 1.12	0.37 ± 0.84	0.48 ± 0.78	1.91 ± 1.06

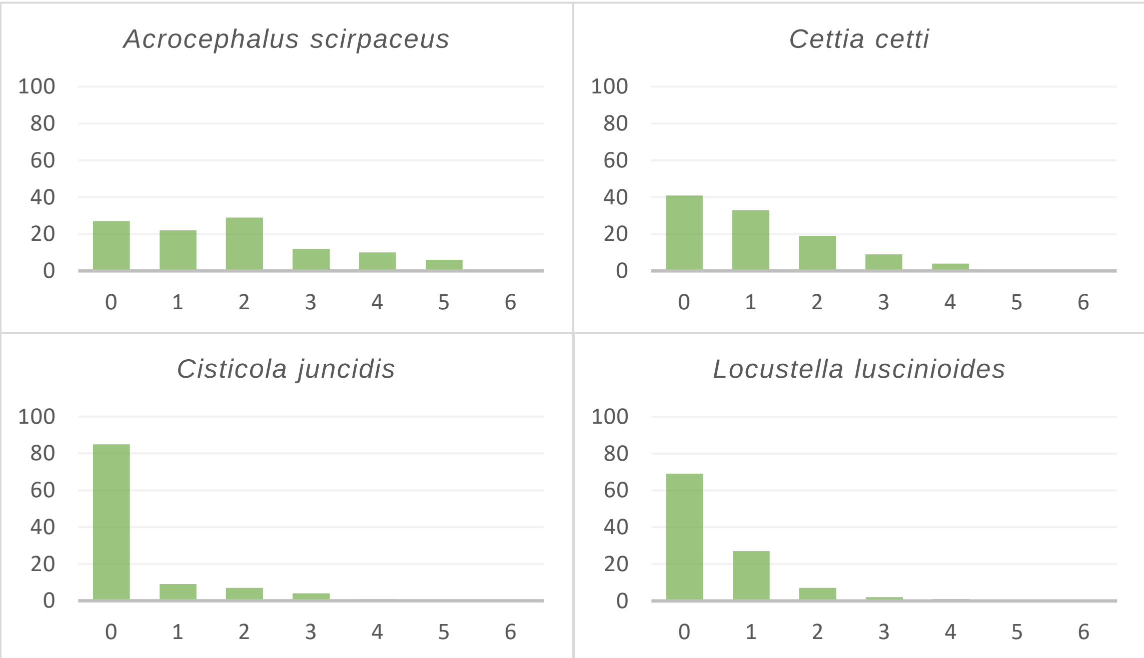

Figure 8: Frequency of the study bird species in percentage according the six visits to the study areas conducted during the breeding season in central-western Portugal. Presence/absence of species per square in the study area. Vertical values are number of square.

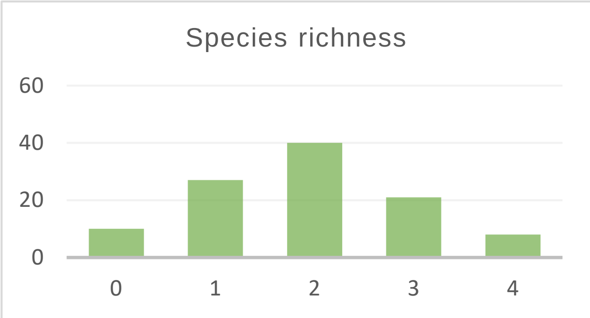

Figure 9: Frequency of species per square in study area. Vertical values are number of squares. Horizontal values are number of species.

For both species, only a single model was found that best describes them (ΔAICc < 2). For the species *A. scirpaceus*, the best model was the one that included only the reed variable (Akaike weight = 0.97; Appendix 1). The frequency of the species was positively and strongly significant in relation to reed height ($z = 3.478$, $p < 0.0001$; Table 3, Appendix 2). As for the species *C. cetti*, the best model was the one that included only the woody plants variable (Akaike weight = 1; Appendix 1). The species frequency was positively and strongly significant in relation to the presence of woody plants ($z = 4.663$, $p < 0.0001$;Table 3, Appendix 2).

For species richness, the best model was the one that included the reed variable (Akaike weight = 0.97; Appendix 1). Bird frequency being positively related to reed height, although relatively weakly significant ($z = 2.348$, $p = 0.0189$; Table 3). In the model averaging results this variable was not significant (Appendix 2).

Table 3: Best model (ΔAICc < 2) results for the frequency of *Acrocephalus scirpaceus* frequency of *Cettia cetti* and Species richness.

Model	**Model parameters**	**Estimate**	**Std. Error**	**Z value**	**p-value**
A. scirpaceus	intercept	-0.001014	0.223072	-0.005	0.9964
	reed	0.321362	0.092403	3.478	< 0.0001
C. cetti	intercept	-0.5500	0.1826	-3.013	0.0026
	woody plants	0.9919	0.2127	4.663	< 0.0001
Species richness	intercept	0.33239	0.15589	2.132	0.0330
	reed	0.17783	0.07574	2.348	0.0189

4. Discussion

The results of this work suggest that the frequency of occurrence and the specific richness of reed passerines in the central-western region of Portugal are influenced by characteristics related to the heterogeneity and dynamics of their nesting habitats.

The most frequent species in the study area was *A. scirpaceus*. According to the results obtained, this species may have been positively influenced by reed height. Some studies refer that the reed height variable has a positive influence on the reproductive success of reed species (Batáry et al., 2004; Neto, 2006; Paracuellos, 2006), as is the case of the species *A. scirpaceus*, which prefers taller reed beds that are better support their nests (Martínez-Vilalta et al., 2002). This preference for higher reeds may be directly related to a lower risk of predation in this type of habitat (Meyer et al., 2010; Darolová et al., 2014; Kameníková et al., 2016), since they provide better protection against air predators (Trnka et al., 2014), although this parameter was not evaluated in my study.

According to the results, the frequency of the species *C. cetti* in the study area was positively related to the presence of woody plants. This bird species breeds in different wetland habitats, with a preference for riparian areas and reed beds, but depends on the presence of woody plants near reeds to provide foraging areas (Balança & Schaub, 2005; Moreno-mateos et al., 2009; Battisti et al., 2019). The reed bed area provides a safe habitat for roosting, reduces the risk of predation and favorable microclimate for breeding (Meyer et al., 2010; Araújo et al., 2016). However, the species avoids the pure reed on the water (Kennerley & Pearson, 2010), maybe due to a lack of building material or the greater difficulty in hiding their nests (Meyer et al., 2010).

The results show that species richness was positively influenced by reed height. Considering the relatively high frequency of *A. scirpaceus* when compared to the other three surveyed species, this species would have had a great contribution to the response of specific richness. This high frequency of *A. scirpaceus* may be indicative of a numerical dominance of the species in the study areas (Hoi et al., 1991). Although species abundances were not assessed in my study, the numerical dominance of a species in a reed bed habitat can have negative consequences for the territory establishment of behaviorally submissive species in the same area (Newton, 1994; Moreno-mateos et al., 2009). Although the results indicate that woody plants have a positive influence in *C. cetti* the available literature suggest that this variables has a positive effects on the richness of wetlands bird communities (Moreno-mateos et al., 2009). However, according to Riegert, (2021), a higher proportion of trees might cause the typical wetland reedbed vegetation to decline. Studies on interspecific competition have revealed that submissive species may start to exploit the resources earlier to gain an advantage over behaviorally-dominant species (Hoi et al., 1991; Cao, 2021). However, it would be important to study interspecific competition to understand its role in establishing the territories of the target species in the study areas.

Contrary to expectations, water frequency did not influence the reed passerine nesting community. In their study, Alambiaga et al., (2021) reports that species such as *A. scirpaceus* and *L. luscinioides* avoided vegetation in wetland areas that did not contain water. Therefore, the presence of water have been identified as an important characteristic for the frequency of these species (Beemster et al., 2010; Zacchei et al., 2011; Mérő, Lontay, et al., 2015; Alambiaga et al., 2021). In fact, water availability influences reed growth and structure, with reeds in shallower water tending to be denser and offering greater nest protection (Meyer et al., 2010; Kameníková et al., 2016). While the results of my study indicate that water frequency had no influence on the frequency of the target species, assessing water availability during the breeding season alone does not provide insight into the availability and habitat preferences of the target species. Furthermore, this variable can be conditioned by meteorological variations, especially in Poças do Vau, which presents greater fluctuations in water level. Thus, several years of study would be necessary to clarify the effect of water level on habitat preference of reed passerines (Jiménez et al., 2018).

The species with the lowest frequency in the study areas were *L. luscinioides* and *C. juncidis*. The lower frequency of *L. luscinioides* may be due to predation risk or habitat specialization (Neto, 2006; Bergner & Gezelius, 2013; Antoniazza et al., 2017). According to a study by Bergner & Gezelius, (2013), in Sweden, the species *L. luscinioides* is more selective in habitat choice due to high predation pressures. In opposition to the species *A. scirpaceus* and *C. cetti*, the species *L. luscinioides* builds its nests at low levels in dense vegetation (Neto, 2006). Second, although the habitat has the preferred characteristics of the species, with vegetation rich in reeds and *Rubus* sp. (Bergner & Gezelius, 2013), the study area is surrounded by agriculture lands, which may have affected its frequency since the species seems to be more sensitive to anthropic disturbances (Antoniazza et al., 2017). Also, the species *L. luscinioides* has lower abundances when compared to other species of reed passerines in other Iberian regions (Martínez-Vilalta et al., 2002). Contrarily to *L. luscinioides*, *C. juncidis* is an habitat generalist which don't present a clear association with the habitat, and may exist in wetlands, fallow land or in dryland agricultural habitats, where it is positively associated with herbaceous vegetation of about 30 cm (Moreira, 1999; Martínez-Vilalta et al., 2002; Battisti et al., 2019). Thus, *C. juncidis* can use the surveyed study areas as an alternative habitat of adjacent agricultural lands. Some studies (e.g. Battisti et al., 2020) mention there has been a trend for the species *C. juncidis* to decline, but these extinctions are only local, as the European population is stable (BirdLife International, 2021).

The results obtained in my study may have been affected by the field methodology. Accordingly, I developed the work only at the wetland edges which may have compromised the detectability of birds and the collection of environmental variables more associated to the center of the patch. The impossibility of evaluating the whole area of wetlands, restricting the study only to the edge, may have been a conditioning factor. However, some studies stating that reed bed birds have a tendency for these species to concentrate more in this area (Báldi, 1999; Bergner & Gezelius, 2013; Méro et al., 2015). Also, the reed tends to be taller and denser at the edge than at the center (Báldi, 1999) recording a microclimate that, besides protecting the nests in adverse conditions, favors the development of many insects and arachnids (Báldi & Kisbenedek, 1999; Bergner & Gezelius, 2013).

4.1. Conservation of the palustrine wetlands

The results of my study suggest that target reed bed species can be good indicators of the conservation status of wetlands, particularly in terms of reed characteristics (height) or landscape heterogeneity (proximity of woody vegetation). The importance of reed bed bird species as suitable bioindications have already been noticed in other Mediterranean wetlands (Battisti et al., 2019). Indeed, these species meet some criteria described by Rüdisser et al., (2012), namely (1) being relatively common species; (2) easy to detect using simple sampling techniques; (3) are sensitive to specific phenomena - such as changes in the dynamics and heterogeneity of a habitat; (4) possibility to compare with other areas. Thus, the absence of *A. arundinaceus* (which is the largest European reed bed passerine) may be indicative of changes in habitat quality, which is a key factor for the nesting of this species (Alambiaga et al., 2021; Mérõ & Žuljević, 2014) suggesting that my study areas may not present the necessary conditions for its reproduction.

The conservation of these palustrine wetlands in Mediterranean should be a priority. Many authors refer to the importance of conservation, restoration, or creation of large heterogeneous reed beds to promote greater diversity of species that depend on these habitats (Paracuellos, 2006; Kingsford et al., 2016; Morganti et al., 2019; Riegert, 2021). This growing concern for Mediterranean wetlands is mainly due to worsening climate change, with increasingly longer periods of drought (Kingsford et al., 2016; IPMA, 2021a) as well as the lack of management in the over-abstraction of water for agriculture (Battisti et al., 2006).

Promoting habitat heterogeneity by increasing native woody species, as well as managing and maintaining a variety of microhabitats in a wetland that meet the specific needs of each species could lead to an increase in wetland-associated species richness and decrease interspecific competition and predation of these species (Morganti et al., 2019; Alambiaga et al., 2021; Musseau et al., 2021). In addition, wetlands that have more surrounding woody vegetation cover tend to have less anthropogenic pressure (Prasad et al., 2021). Some authors also suggest that the practice of reed bed management and maintenance through a controlled cutting or burning of reeds outside the breeding season and promoting a better development of emergent vegetation (Neto, 2003; Morganti et al., 2019).

5. Conclusion

In the present study, the influence of dynamics and heterogeneity on reed passerines in Paul de Tornada Natural Reserve and Poças do Vau was evaluated, suggesting that these two variables are important in understanding the conservation status of these wetlands. The frequency of reed passerine species is also a reflection of the habitat conditions in these areas demonstrating that it is important that measures be taken to preserve these wetlands.

In order to improve the conservation status of these areas, I propose to improve botanical diversity by planting native species associated with wetlands. Furthermore, it would be important that, like Paul, Poças be considered an area of importance for the conservation of reed beds in the country, as well as the bird species that depend on them, being one of the few wetland areas that still resist the strong anthropic pressures of the region.

Another important measure would be to conduct further studies to better understand the level of degradation of these habitats, as well as to raise the awareness of the population for the correct use of these areas to conserve these habitats of high ecological importance.

6. References

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7. Appendixes

Appendix 1: Component models

as.factor (water)	as.factor (Woody plants)	reed
1	2	3

Acrocephalus scirpaceus

	df	logLik	AICc	delta	weight
3	3	-173.71	353.65	0.00	0.97
1	8	-171.67	360.83	7.18	0.03
(Null)	2	-180.66	365.43	11.78	0.00
2	3	-180.04	366.31	12.66	0.00
	Cettia cetti				
	df	logLik	AICc	delta	weight
2	3	-135.40	277.03	0.00	1
3	3	-141.35	288.94	11.92	0
(Null)	2	-145.41	294.93	17.91	0
1	8	-138.82	295.12	18.09	0
	Species richness				
	df	logLik	AICc	delta	weight
3	3	-159.66	325.56	0.00	0.79
(Null)	2	-162.50	329.12	3.56	0.13
2	3	-162.50	331.23	5.68	0.05
1	8	-157.13	331.74	6.18	0.04

Appendix 2: Model-averaged coefficients of the species *Acrocephalus scirpaceus, Cettia cetti* and Species richness

		Estimate	Std. Error	Adjusted SE	z value	Pr(>|z|)
Acrocephalus scirpaceus	(Intercept)	-0.0045556	0.2368929	0.2395397	0.019	0.98483
	reed	0.3113622	0.1067063	0.1076294	2.893	0.00382**
	as.factor(water)1	0.0226258	0.1746156	0.1754659	0.129	0.89740
	as.factor(water)2	0.0488158	0.3033732	0.3035878	0.161	0.87225
	as.factor(water)3	0.0240696	0.1596116	0.1599547	0.150	0.88039
	as.factor(water)4	0.0250082	0.1624905	0.1627696	0.154	0.87789
	as.factor(water)5	0.0303072	0.2075885	0.2081702	0.146	0.88425
	as.factor(water)6	0.0236558	0.1570367	0.1573779	0.150	0.88052
	as.factor(woody plants)1	-0.0003224	0.0104050	0.0104603	0.031	0.97542
Cettia cetti	(Intercept)	-5.497e-01	1.832e-01	1.853e-01	2.966	0.00301**
	as.factor(woody plants)1	9.891e-01	2.188e-01	2.213e-01	4.470	7.8e-06***
	reed	8.029e-04	1.687e-02	1.690e-02	0.048	0.96210
	as.factor(water)1	6.572e-05	1.050e-02	1.058e-02	0.006	0.99505
	as.factor(water)2	1.810e-05	8.729e-03	8.834e-03	0.002	0.99836
	as.factor(water)3	2.422e-06	5.613e-03	5.683e-03	0.000	0.99966
	as.factor(water)4	4.525e-05	6.140e-03	6.182e-03	0.007	0.99416
	as.factor(water)5	-1.568e-05	1.159e-02	1.173e-02	0.001	0.99893
	as.factor(water)6	1.150e-04	1.135e-02	1.137e-02	0.010	0.99193
Species richness	(Intercept)	0.3753160	0.2158867	0.2172239	1.728	0.084
	reed	0.1397302	0.0991499	0.0996921	1.402	0.161
	as.factor(woody plants)1	0.0001736	0.0387501	0.0392105	0.004	0.996
	as.factor(water)1	0.0273745	0.1786561	0.1794756	0.153	0.879
	as.factor(water)2	0.0376386	0.2132933	0.2137178	0.176	0.860
	as.factor(water)3	0.0315769	0.1761123	0.1764025	0.179	0.858
	as.factor(water)4	0.0266537	0.1505787	0.1508686	0.177	0.860
	as.factor(water)5	0.0353360	0.2088738	0.2094681	0.169	0.866
	as.factor(water)6	0.0273745	0.1528726	0.1531289	0.179	0.858