Universidade de Évora

Escola de Ciências e Tecnologia

Mestrado em Biologia da Conservação

Dissertação

Avaliação da influência altitudinal nas comunidades de aves dos montados de sobro em Portugal: aspectos biogeográficos e ecológicos

Ana Luísa Teixeira de Figueiredo Catarino

Orientador:

Prof. Doutor João Eduardo Morais Gomes Rabaça

Co-orientadores:

Prof. Doutor António Manuel da Silva Luís

Mestre Carlos António Marques Pereira Godinho

2013

Mestrado em Biologia da Conservação

Dissertação

Avaliação da influência altitudinal nas comunidades de aves dos montados de sobro em Portugal: aspectos biogeográficos e ecológicos

Ana Luísa Teixeira de Figueiredo Catarino

Orientador:

Prof. Doutor João Eduardo Morais Gomes Rabaça

Co-orientadores:

Prof. Doutor António Manuel da Silva Luís

Mestre Carlos António Marques Pereira Godinho

AGRADECIMENTOS

Em primeiro lugar não poderia deixar de agradecer aos meus orientadores, João Eduardo Rabaça, António Luís e Carlos Godinho pela disponibilidade que apresentaram em me orientar neste trabalho, desde o aconselhamento nas metodologias de campo até às várias revisões da dissertação.

À Companhia das Lezírias S.A., agradeço a autorização que foi dada para a realização do trabalho de campo na propriedade, em particular ao Engenheiro Rui Alves.

Ao Centro de Biologia Ambiental agradeço a possibilidade de usar as instalações da Herdade da Ribeira Abaixo.

Quero também agradecer ao senhor António e à sua esposa que tão amavelmente me emprestaram a sua casa durante o trabalho de campo em Romeu e que no fim ainda me presentearam com umas deliciosas alheiras caseiras.

Um agradecimento especial ao Carlos e ao Pedro pela disponibilidade que sempre demonstraram para me ajudar em todo este projecto. Agradeço todos os conhecimentos e concelhos dados durante a escrita da dissertação, o apoio durante o trabalho de campo e todos os dados cedidos.

Obrigada a todos os meus amigos que de uma forma ou outra me foram apoiando ao longo deste ano.

Não posso deixar de agradecer aos meus pais. Sem eles nada disto teria sido possível. Em especial à minha mãe pela companhia e boa disposição, mesmo tendo de se levantar de madrugada para vir comigo ao campo.

Muito obrigada.

ÍNDICE

Biogeographical and ecological features of breeding bird communities in cork oak forested areas

A. ÍNDICE DE FIGURAS

B. ÍNDICE DE TABELAS

C. RESUMO

Avaliação da Influência altitudinal nas comunidades de aves dos montados de sobro em Portugal: aspectos biogeográficos e ecológicos

Os montados são sistemas agro-silvo-pastoris de origem antropogénica dominados pelo sobreiro (*Quercus suber*) e/ou azinheira (*Q. rotundifolia*). São considerados sistemas de Elevado Valor Natural (*High Nature Value*, HNV) e estão incluídos no Anexo I da Directiva Habitats da União Europeia (92/43/CEE). No entanto, alguns montados estão ameaçados devido ao abandono da terra, sobre-pastoreio e agentes patogénicos. Vários estudos têm demonstrado que a distribuição das aves nos montados está relacionada com a gestão das florestas e áreas agrícolas. Estes habitats são conhecidos por terem uma elevada riqueza de aves florestais e também espécies de áreas abertas. Com este estudo podemos concluir que a diversidade de espécies lenhosas beneficia o aparecimento de espécies de aves com diferentes requisitos de habitat. Demonstrou-se também que não existe uma relação significativa entre a distribuição da comunidade de aves e a altitude na nossa área de estudo. E por último, as espécies especialistas do sobreiro podem ser consideradas bioindicadores de áreas bem preservadas de montado uma vez que existem em maiores densidades quando o insecto *C. florentinus* aparece em menor frequência.

D. ABSTRACT

Assessment of the altitudinal influence in bird communities of cork oak forested areas in Portugal: biogeographical and ecological aspects

The *montados* are agro-silvo-pastoral systems of anthropogenic origin dominated by cork oak (*Quercus suber*) and/or holm oak (*Q. rotundifolia*). They are considered High Nature Value Farmlands (HNVF) and are included in Annex I of the European Union Habitats Directive (92/43/CEE). Nevertheless, some of these habitats are threatened by land abandonment, overgrazing and pathogenic agents. Several studies have shown that bird distribution in *montados* is related to forest and farmland management. These habitats are known to have high richness in breeding birds as they encompass not only forest but also farmland species. However, the effects of landscape composition on avian communities in forest dominated landscapes are not well studied. With this study we can conclude that the diversity of woody species benefits the appearance of bird species with different habitat requirements. It was also demonstrated that there is no significant relation between the distribution of bird communities and altitude in our study area. Finally, cork oak specialists can be considered as bioindicators of well-preserved *montados* since they exist at greater densities when the insect *C. florentinus* appears less frequently.

E. INTRODUÇÃO GERAL

Os montados (e as "dehesas" em Espanha) são sistemas agro-silvo-pastoris de origem antropogénica dominados pelo sobreiro (*Quercus suber*) e/ou azinheira (*Quercus rotundifolia*), normalmente com pastagens em subcoberto (Olea & Miguel-Ayanz, 2006; Bugalho *et al*., 2009; Pinto-Correia *et al*., 2011). Estes sistemas agro-silvo-pastoris combinam o uso de produtos florestais (madeira, carvão e cortiça) com culturas de cereais e pastoreio no sub-bosque (Blondel & Aronson, 1999). Este sistema dinâmico e multifuncional forma uma paisagem heterogénea de matriz florestal com áreas abertas, bosques dispersos, áreas de floresta e matos mediterrânicos sem perturbação, permitindo que estas áreas suportem uma enorme diversidade biológica (Rabaça, 1990; Blondel & Aronson, 1999; Tellería, 2001; Díaz *et al*., 2003; Telleria *et al.*, 2003; Harrop, 2007). Esta diversidade deve-se ao facto dos montados serem submetidos frequentemente a diversas actividades de gestão ao longo do ano, ao contrário do que acontece com outros sistemas de produção de madeira como nas florestas de pinheiros (*Pinus* spp.) (Scarascia-Mugnozza *et al*., 2000), aumentando a sua complexidade com a combinação de outras actividades de produção como por exemplo a agricultura, o pastoreio, criação de animais, etc. (Correia, 1993).

Os montados são considerados sistemas de Elevado Valor Natural (*High Nature Value*, HNV) (Hoogeveen *et al*., 2004) e estão incluídos no Anexo I da Directiva Europeia Habitats da União Europeia (92/43/CEE). No entanto, uma parte expressiva destas áreas encontra-se ameaçada devido ao abandono da terra, sobre-pastoreio e por pragas florestais (Plieninger, 2007). De entre as pragas, as mais relevantes são as produzidas por fungos da espécie *Biscogniauxia mediterranea*, pelos insectos *Coroebus undatus* e *Coroebus florentinus*, e alguns besouros da madeira, principalmente Cerambycidae e Platypodidae, sendo responsáveis pela desfolha da copa, reduzida qualidade da cortiça e mortalidade das árvores (Ferreira & Ferreira, 1991).

Em Portugal, as áreas de sobreiro ocupam uma superfície de cerca de 737 000 ha (DGRF, 2007) estando distribuídas principalmente no centro e sul do país, apesar de se poderem encontrar algumas manchas de montados bem preservados no norte. Esta distribuição é resultado de condições climáticas e do solo, mas também da acção humana, uma vez que a distribuição potencial do sobreiro abrange a maior parte do país (Natividade, 1950; Costa & Pereira, 2007).

Os montados são muito importantes para as aves, sendo o habitat com maior riqueza de aves nidificantes da Península Ibérica (Tellería, 2001) e fora da época de reprodução representam também um habitat importante para um grande número de espécies migratórias (Díaz *et al*., 1997). O aumento da presença de aves de áreas abertas e de orla em montado parece compensar a perda de espécies florestais (Tellería, 2001). Além disso, as aves parecem estar bem adaptadas a este sistema, mostrando até tolerância ao descortiçamento (Godinho & Rabaça, 2011; Leal *et al*., 2011).

Vários estudos têm mostrado que a distribuição de aves está relacionada com características do habitat (Díaz, 2006; Gil-Tena *et al*., 2007; Godinho & Rabaça, 2011). Godinho & Rabaça (2011) concluíram que áreas com diferentes densidades de árvores, pequenas manchas de arbustos mediterrânicos no sub-bosque e um número de cabeças de gado equilibrado providenciam habitat para várias espécies de aves. A estrutura complexa do montado favorece a ocupação por espécies de diferentes nichos ecológicos no interior da floresta. Por exemplo, num bosque com uma estrutura vertical pouco desenvolvida, aves que se alimentam no solo como o tentilhão (*Fringilla coelebs*), a cotovia-dos-bosques (*Lullula arborea*) e o trigueirão (*Emberiza calandra*) dominam (Rabaça, 1990; Tellería, 2001). Algumas espécies de toutinegras (*Sylvia* spp.) e a carriça (*Troglodytes troglodytes*) são mais abundantes nas áreas com vegetação arbustiva mais desenvolvida (Rabaça, 1990; Tellería, 2001). Existem espécies que se alimentam principalmente na copa das árvores como os chapins-azuis (*Parus caeruleus*), os chapins-reais (*Parus major*) e a felosinha-comum (*Phylloscopus collybita*) (Almeida & Granadeiro, 2000) e, finalmente, a trepadeira-azul (*Sitta europaea*) e a trepadeira-comum (*Certhia brachydactyla*) que se alimentam principalmente no tronco (Almeida, 1992). Pereira *et al*. (2012) sugerem que o aumento da diversidade de árvores pode melhorar a adequação do habitat para espécies como a felosa-de-papo-branco (*Phylloscopus bonelli*) e que povoamentos mistos de sobreiro com pinheiros podem trazer benefícios monetários aos proprietários. Permitindo assim a conciliação entre a exploração económica e a conservação da biodiversidade e, eventualmente reduzir o impacto da desfolha das árvores.

No entanto, existem lacunas de conhecimento sobre os efeitos da composição da paisagem nas comunidades de aves destes habitats (Rodewald & Yahner, 2001; Díaz, 2006), nomeadamente sobre qual a relação entre o efeito da gestão florestal e a diversidade de vida selvagem, o efeito das opções de gestão da biodiversidade ao nível

da paisagem e também as interacções estruturais e funcionais entre a gestão das áreas e a diversidade biológica (Scarascia-Mugnozza *et al*., 2000).

Com o objectivo de avaliar a influência (1) das características geográficas e altitudinais, (2) da composição e estrutura da vegetação lenhosa e (3) da ocorrência de pragas de insectos nas comunidades de aves nidificantes dos montados de sobro, realizámos censos de aves em quatro áreas diferentes. Os locais de amostragem foram seleccionados ao longo da área de distribuição do sobreiro em Portugal e procurámos abranger um bom gradiente altitudinal e latitudinal. Na área mais setentrional amostrámos o Sítio de Importância Comunitária (SIC) de Romeu (7º 1'-7º 6'W and 41º 33'-41º 28'N); a sul a Serra de Grândola (8º 34'-8º 38' W and 38º 9'-38º 08' N), no centro a Companhia das Lezírias (8°48'W and 38°50'N) e no interior a Serra de Monfurado (7° 40'–8° 16'W and 38° 27'–38° 41'N) (Fig. 1). A Companhia das Lezírias é uma empresa agrícola de propriedade pública, a Serra de Monfurado e Romeu são áreas da Rede Natura 2000 e a Serra de Grândola encontra-se dentro de uma das maiores áreas de montado de sobro contínuo, em Portugal.

Nestes locais realizámos pontos de escuta (Bibby *et al*., 2000) para determinar a riqueza das comunidades de aves nidificantes e os valores de abundância das diversas espécies. Para facilitar a análise dos dados e também para verificar como é que as espécies de aves se comportavam em conjunto, criámos quatro guildas ecológicas, de acordo com o seu habitat preferencial (agrícola, florestal, arbustivo e especialista do sobreiro) tendo por base o Atlas das Aves nidificantes de Portugal (Equipa Atlas, 2008) e experiência dos observadores. Avaliámos também a estrutura da vegetação em termos de cobertura e densidade e as manifestações das pragas de insectos, com base na sua presença ou ausência nas áreas de estudo.

Numa primeira fase os dados foram analisados através de uma Análise de Correspondência Canónica (CCA) (ter Braak, 1986) de forma a identificar as variáveis ambientais que contribuem de forma mais significativa para a variância observada na comunidade de aves. Posteriormente, utilizando as variáveis mais importantes obtidas na CCA (altitude, densidade da vegetação, diâmetro à altura do peito, cobrilha dos ramos, cobrilha da cortiça, riqueza de espécies lenhosas e o descortiçamento), realizámos regressões lineares com as espécies mais representativas das guildas florestais, especialistas do sobreiro, arbustiva e agrícola (número de casais por área).

Após a análise realizada espécie a espécie, aferimos a relação das quatro guildas nas quatro áreas de estudo através do método one-way ANOVA (Zar, 1999).

F. ARTIGO CIENTÍFICO

Biogeographical and ecological features of breeding bird communities in cork oak forested areas

Catarino L[2], Godinho C[1,2], Pereira P[1,2], Luís A[3], and Rabaça JE[1,2]

[1] ICAAM - Instituto de Ciências Agrárias e Ambientais Mediterrânicas, Universidade de Évora, Núcleo da Mitra, Ap. 94, 7002-554 Évora, Portugal

[2] LabOr – Laboratório de Ornitologia, Departamento de Biologia, Universidade de Évora 7002-554 Évora, Portugal

[3] Departamento de Biologia, Universidade de Aveiro, Campus de Santiago, 3810-193 Aveiro, Portugal

1. Abstract

The Portuguese *montados* and Spanish 'dehesas' are agro-silvo-pastoral systems of anthropogenic origin dominated by cork oak (*Quercus suber*) and/or holm oak (*Q. rotundifolia*). They are considered High Nature Value Farmlands (HNVF) and are included in Annex I of the European Union Habitats Directive (92/43/CEE). Nevertheless, some of these habitats are threatened by land abandonment, overgrazing and pathogenic agents. Several studies have shown that bird distribution in *montados* is related to forest and farmland management. These habitats are known to have high richness in breeding birds as they encompass not only forest but also farmland species. However, the effects of landscape composition on avian communities in forest dominated landscapes are not well studied. With this study we can conclude that the diversity of woody species benefits the appearance of bird species with different habitat requirements. It was also demonstrated that there is no significant relation between the distribution of bird communities and altitude in our study areas. Finally, cork oak specialists can be considered as bioindicators of well-preserved *montados* since they exist at greater densities when the insect *C. florentinus* appears less frequently.

Keywords: *montados*, birds, management, pathogenic agents, landscape composition

2. Introduction

The Portuguese *montados* and Spanish 'dehesas' are agro-silvo-pastoral systems of anthropogenic origin dominated by cork oak (*Quercus suber*) and/or holm oak (*Quercus rotundifolia*) trees, usually with a groundcover of grazed grasslands (Olea & Miguel-Ayanz, 2006; Bugalho *et al.*, 2009; Pinto-Correia *et al*., 2011). These agro-silvo-pastoral systems combine the use of woodland products (timber, charcoal and cork) with cereal crops and livestock grazing in the understory (Blondel & Aronson, 1999). This dynamic and multifunctional system creates a heterogeneous landscape of wooded matrix with open areas, scattered woodlands and undisturbed patches of Mediterranean forest and scrublands, allowing these areas to support a high biological diversity (Rabaça, 1990; Blondel & Aronson, 1999; Tellería, 2001; Díaz *et al*., 2003; Telleria *et al.*, 2003; Harrop, 2007). This is due to the fact that *montados* have diverse and more frequent management activities through the year rather than wood production systems like pine (*Pinus* spp.)(Scarascia-Mugnozza *et al*., 2000), and their complexity increases with the combination of other production activities (e.g. agriculture, pasture, grazing, animal stock, etc.)(Correia, 1993).

They are considered High Nature Value Farmlands (HNVF) (Hoogeveen *et al*., 2004) and are included in Annex I of the European Union Habitats Directive (92/43/CEE). Nevertheless, several of these forested areas are threatened by land abandonment, overgrazing and pathogenic agents (Plieninger, 2007). Among these the most relevant are the fungal species *Biscogniauxia mediterranea*, the insects *Coroebus undatus* and *Coroebus florentinus*, and some wood beetles, mostly Cerambycidae and Platypodidae, responsible for canopy defoliation, cork quality reducing and tree mortality (Ferreira & Ferreira, 1991).

In Portugal, cork oak woodland occupies an area of c. 737 000 ha (DGRF, 2007) and its distribution is mainly in the central and south of the country, although some patches of well-preserved *montados* can be found in the north. This distribution results from soil and climate conditions, but also from human actions since cork oak as a potential distribution across most of the country (Costa & Pereira, 2007).

Montados are habitats with the highest richness in breeding birds in the Iberian Peninsula (Tellería, 2001) and outside the breeding season they are a key habitat for a great number of migratory species (Díaz *et al*., 1997). Additionally, the presence of

edge and open area birds appears to compensate the loss of forest species (Tellería, 2001). Besides that, birds are well adapted to this system and they even show a tolerance to cork debark (Godinho & Rabaça, 2011; Leal *et al*., 2011).

Several studies have shown that bird distribution is related to forest habitat features (Díaz, 2006; Gil-Tena *et al*., 2007; Godinho & Rabaça, 2011). Godinho & Rabaça (2011) conclude that areas with different tree densities, small patches of Mediterranean shrubs in the understory and well balanced livestock numbers provide suitable habitat for several bird species. The complex physiography of the *montado* endorses the species occupancy by different ecological niches inside the woodland matrix. For instance, under a poorly developed understory, ground feeders like chaffinches (*Fringilla coelebs*), woodlarks (*Lullula arborea*) and corn buntings (*Emberiza calandra*) dominate (Rabaça, 1990; Tellería, 2001). On the other hand, some warbler species and wrens (*Troglodytes troglodytes*) are more abundant in areas with developed understory vegetation (Rabaça, 1990; Tellería, 2001). Then, there are species that feed mainly on the canopy like the blue tits (*Parus caeruleus*), great tits (*Parus major*) and the wintering chiffchaffs (*Phylloscopus collybita*) (Almeida & Granadeiro, 2000), and finally the wood nuthatch (*Sitta europaea*) and the short-toed tree-creeper (*Certhia brachydactyla*) that feed mostly on cork, the bark of the tree (Almeida, 1992). Pereira *et al*. (2012), also verified that the increase of tree diversity can improve habitat suitability for leaf-warblers like Bonelli's warbler (*Phylloscopus bonelli*), and mixed stands of cork oak and pines may give additional incomes for landowners, facilitating the conciliation between economic exploitation and wildlife conservation, and eventually reduce the defoliator's impact. However, there is still the need to do applied studies on the effects of landscape composition on avian communities in forest dominated landscapes (Rodewald & Yahner, 2001; Díaz, 2006).

In order to evaluate the influence of (1) geographical and altitudinal features, (2) woody vegetation and (3) occurrence of insect pests in breeding bird communities of cork oak forested areas, we surveyed four sites along the latitudinal gradient of cork oak distribution in Portugal.

3. Methods

3.1. Study area

Our study was conducted in Romeu (Northeast, 7º 1'-7º 6'W and 41º 33'-41º 28'N), Companhia das Lezírias (Center, 8°48'W and 38°50'N), Serra de Monfurado (Southeast, 7° 40'–8° 16'W and 38° 27'–38° 41'N) and Serra de Grândola (Southwest Portugal, 8º 34'-8º 38' W and 38º 9'-38º 08' N). Climate in these areas is typically Mediterranean with hot and dry summers and moderate rainy winters. Altitude among areas ranges between 15 and 600 m, Companhia das Lezírias is the one with the softer slope (15 to 50 m) and Romeu with the highest altitudes (300 to 600 m). The northeast (Romeu) and the southeast (Serra de Monfurado) areas showed the lowest mean annual temperature (12.3ºC and 12.5ºC, respectively) and the highest levels of mean annual precipitation (760 and 800 mm, respectively), while the remaining areas have a mean annual temperature higher, with 15.7ºC for Companhia das Lezírias and 15.6ºC for Serra de Grândola and lower levels of mean annual precipitation (644 and 500 mm, respectively). The woodland area is always dominated by cork oaks, with the exception of Monfurado where it also appears holm oak settlements, and some mixed stands with Maritime (*Pinus pinaster*) and Stone Pine (*Pinus pinea*) in Companhia das Lezírias. Other land uses vary with geographical location being the most common: rice, vineyards and pine wood in Companhia das Lezírias, olive groves, small orchards, cereal fields and fallows in Monfurado, olive groves and vineyards in Romeu. In this area, unlike the others, there is no livestock grazing.

3.2. Bird census

Bird censuses were carried once during the breeding seasons of 2011 and 2012, between April and May. Data on bird species was gathered using 10 min point counts (*e.g.* Bibby *et al.*, 2000) with 100 m radius and all points were separated by at least 500 m to minimize the probability of double counting. Surveys were conducted between 6:00 and 11:00 a.m., when birds are more active and days with bad weather, like hard wind and rain, were avoided. In each one of the areas we surveyed 30 sites except in Romeu (Northeast) where we sampled 27. Surveys were conducted by 3 experienced observers with similar skills of bird detection.

Communal birds (*e.g.* spotless starling *Sturnus unicolor* and bee-eater *Merops apiaster*), aerial-feeding birds (*e.g.* barn swallow *Hirundo rustica*) and species with large home-range (*e.g.* carrion crow *Corvus corone* and raven *Corvus corax*) were excluded from data treatment. The remain bird species were grouped in four ecological guilds, according to their habitat specialization (OA - **Open Area**, SH – **Shrub**, FO – **Forest**, CS – **Cork oak specialist**), adapted from Equipa Atlas (2008) and authors personal experience. In the cork oak specialist guild we included species that occur in higher densities in cork oak woodlands, presenting a high overlap between their distributions (Equipa Atlas, 2008). We calculate the density of each bird species using only the males that were defending their territories during the census period (*e.g.* Bibby *et al*., 2000).

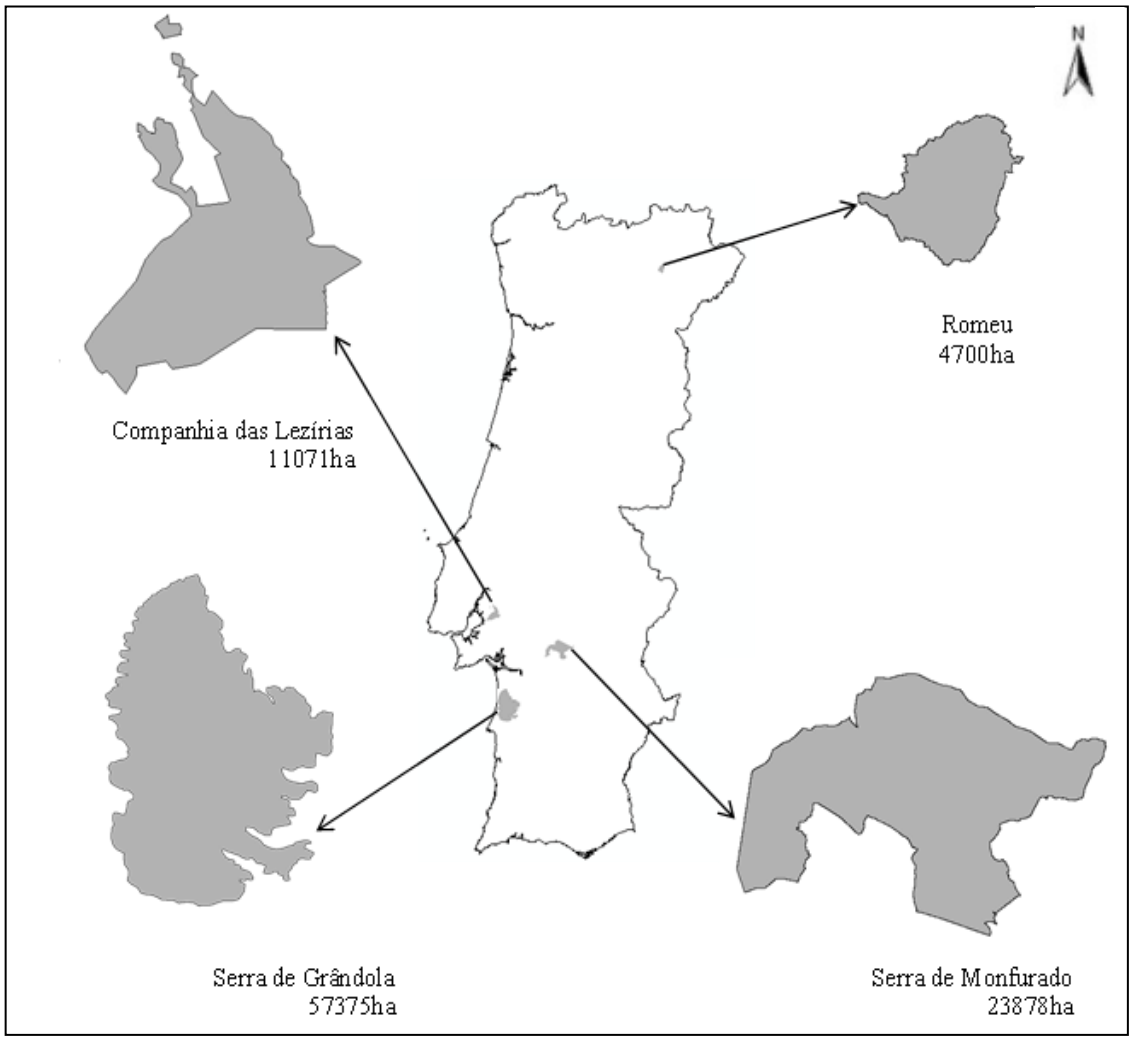

Figure 1 - Location of the study areas.

3.3. Vegetation features and management practices

In order to associate birds' occurrence with site features, the vegetation structure was characterized right after the bird censuses within a 100 m radius around the centre of the bird point count. We counted the number of **dead trees** and estimated the cover of several vegetation layers considering three classes of **height** (**<0.5, 0.5-2, 2-8 m**), five classes of **density** (**0%, 0-15%, 15-30%, 30-60%, 60-100%**) and the **dominant species**. A **vegetation density** index was calculated taking account the classes of height and density. We attributed a value to each class of height (lower: 1, middle: 3 and higher: 5), which was multiplied by a density factor of 0, 1, 2, 3 and 4 according to the percentage of cover (*e.g.* factor 4 corresponds to the higher class of **vegetation density**). The index is the sum of all multiplications. We determined the age and health status for five oaks randomly selected according to their trunk diameter at breast height (**DBH**; cm) and presence of ***Biscogniauxia mediterranea***, respectively. We also noted **cork removal**, **geographical location** and **altitude** of each point (GPS).

3.4. Insect pest's survey

In order to assess the sanitary status of the stands surveyed we conducted visual assessment in five oaks separated by 10 m from each other, avoiding trees with adjoined crowns. The Buprestid ***C. florentinus*** damage was identified by the presence of typical small dead branches on outer-canopy and ***C. undatus*** by the presence of feeding galleries of larvae under cork layer. Beetle holes on trunks were recorded according to their size: ≤ 2mm diameter for **bark beetle's** presence (Platypodidae); larger diameters for **Cerambycids** (Cerambycidae).

3.5. Data analysis

Prior to data analysis, in order to avoid multicollinearity among variables, we performed data reduction procedures. According to Tabachnick & Fidell (2001) all pairwise correlations were assessed by Spearman correlation coefficients and in each pair of highly correlated variables ($r>|0.7|$) only one was retained for further analyses. In order to evaluate the importance of environmental variables to the bird community we

performed canonical ordination techniques for multivariate analysis using the program CANOCO for Windows, version 4.5 (Smilauer & ter Braak, 2002). Selected bird groups were related to the environmental variables using Canonical correspondence analysis (CCA) so as to identify which sets of environmental variables explained the patterns of variation in bird community (ter Braak, 1986). Four initial CCA were performed, either using each environmental group separately (vegetation, insect pests and geographic) or the whole set of variables. Runs were made without data transformation of the bird data, and forward selection of variables under an unrestricted model with a Monte Carlo test (999 permutations) was conducted. We removed variables that did not contribute significantly to the explained variation, with weaker species-explanatory correlations (Titeux *et al*., 2004), and retained variables with an estimated *p*-value lower than 0.05 (*e.g.* Godinho *et al*., 2010).

In accordance with Titeux *et al*. (2004), with this kind of approach, rare or ubiquitous species should not be included in the analysis, because they can influence the analysis to an excessive degree, creating modifications in the total inertia of the species data-set or distortion in the ordination. As we did not have any species recorded for more than 90% of the sampling sites, we only omitted from analysis those species that appeared at fewer than 5% in one of the sampling sites.

In the following analyses we used the most significant variables retained in the CCA. In order to evaluate the effect of insect outbreaks, debark, trunk diameter, vegetation features and altitude (environmental variables) on bird guilds and more specifically on a group of birds, we performed several statistical analyses using SPSS 21 for Windows (IBM Corp., 2012). We choose a set of birds that could characterize their guild, presenting a good rate of occurrence. So, to represent the forest guild we choose *Dendrocopos major*, *Lullula arborea*, *Phylloscopus ibericus*, *Parus caeruleus*, *Parus major*, *Certhia brachydactyla* and *Fringilla coelebs*; for cork oak specialist guild species were *Dendrocopos minor* and *Sitta europaea*; *Sylvia melanocephala* and *Emberiza calandra* represented the shrub and open area guilds, respectively. The variables listed above were modelled in function of these species through linear regression analysis. One-way ANOVA (Zar, 1999) was used to evaluate if there were differences between areas in terms of guilds and environmental variables.

4. Results

4.1. General results

From all the seventy four species recorded in surveys, thirty-eight were used in the analyses and from this point we will refer only to those. Fifteen of them were detected in all areas. In contrast, three bird species were detected only in Romeu, two only in Serra de Monfurado and one in Companhia das Lezírias. The average species richness and standard deviation, per point count, was 7.5±2.1 in Companhia das Lezírias, 6.1±1.0 in Serra de Grândola, 9.8±2.5 in Serra de Monfurado, and 6.9±1.3 in Romeu. The most frequent species were chaffinch *Fringilla coelebs* (68%) and blue tit *Parus caeruleus* (68%); and the less frequent rock bunting *Emberiza cia* (2%) and dartford warbler *Sylvia undata* (2%).

4.2. Canonical correspondence analysis

The CCA ordination results along the first two axes are plotted in Fig. 2. Arrows represent the environmental variables included in the model that explain most variation in the species distribution. The relative importance of each variable in the model is expressed by the length of its corresponding arrow. The arrow's direction relative to the axes shows how well the environmental variable is correlated with each axis. The environmental condition associated with the presence of each species is indicated by the proximity of bird species scores to the arrows.

The first axis accounted for 23.5% of the extracted variance of the species-environmental relationship, and 69% was the value explained for the four axes. The ability of environmental variables to explain variations in bird community composition is expressed in Table 1 and according to the Monte Carlo test, both the first canonical axis and the whole set of canonical axes explained significant bird assemblage data (*P* value < 0.01).

Table 1 – Canonical eigenvalues, species variance and total explained variance for the first two axes of the canonical correspondence analysis

	Axis I	Axis II	Total variance explained (%)
Canonical eigenvalues	0.175	0.143	19.92
Species-environmental correlation	0.827	0.775	

In the negative direction the second axis was mainly influenced by the insect pest ***Coroebus florentinus*** and in the opposite direction, by the presence of shrub vegetation (***Daphne gnidium*** and a set of small Cistus species - ***Lesser Cistus***) and high vegetation cover (more than 50%) in the category 2-8 m (variables: **>50% veg cover** and **>80% veg cover**). Nearly all **open area** species (triangles) were negatively correlated with areas of high and closed shrub and positively correlated with ***C. florentinus***. **Cork oak specialists** (empty stars) were positively correlated with Serra de Grândola, **elevation** and areas of shrub; and negatively correlated with ***C. florentinus***. European robin *Erithacus rubecula*, subalpine warbler *Sylvia cantillans* and rock bunting *Emberiza cia* are exclusive of Romeu and are positively correlated with the shrub species ***Cytisus multiflorus*** which appears mainly in this area. Serra de Monfurado makes the separation between **open area** and **forest** bird guilds. The species *Sylvia melanocephala* and *Hippolais polyglotta*, which are generalist shrub species, are between these guilds.

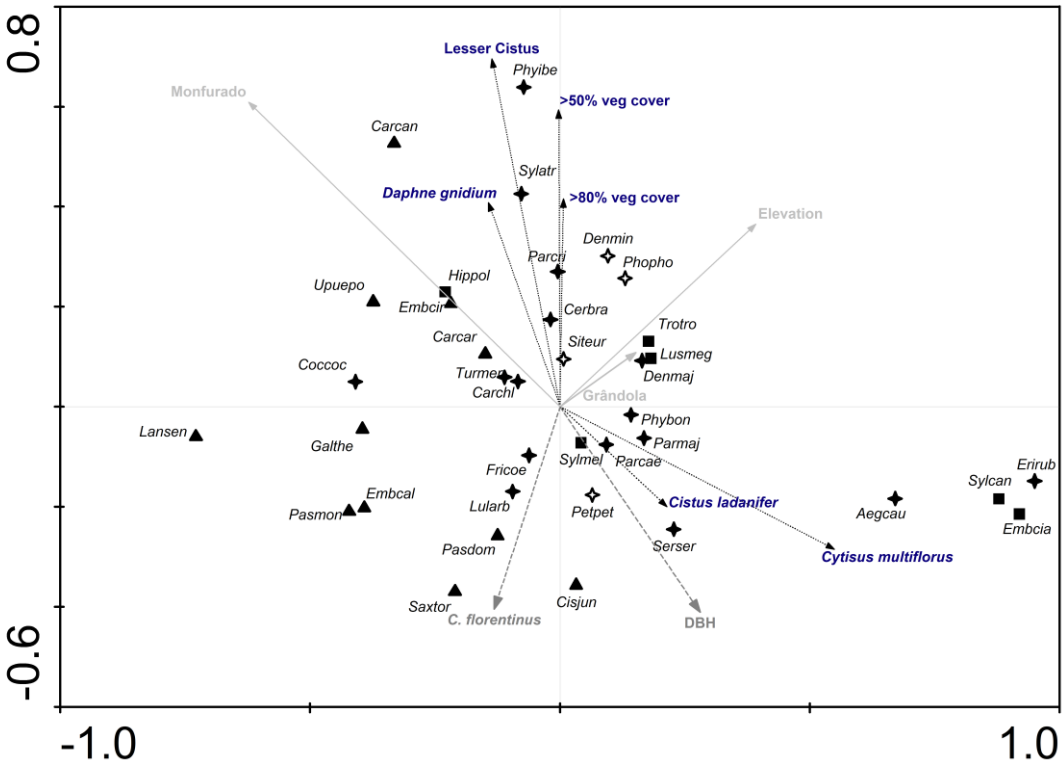

Figure 2 - Canonical correspondence analysis ordination diagram with birds guilds (Forest - filled stars; Cork oak specialist - empty stars; Open area – triangles; Shrub - squares) and environmental variables (arrows): geographical features (solid line), vegetation characteristics (dotted line), trunk diameter (DBH) and insect outbreak *C. florentinus* (dashed line). Vegetation cover (>50% veg cover and >80% veg cover) corresponds to the category of 2-8 m. For species codes see Table 5 on the appendix.

4.3. Linear regression

In order to evaluate if there is any correlation between environmental variables and bird species we performed linear regressions. The results are presented in Table 2.

Table 2 – Linear regression modeling results for a set of species and the environmental variables associated, presenting the regression coefficients (*B*), standard error (SE) and the significance value (*P*). See Table 5 on the appendix for species codes.

	Altitude			**Vegetation density**			**Woody richness**			**DBH**			**Cork removal**			***C. florentinus***			***C. undatus***		
Species	*B*	SE	*P*	*B*	SE	*P*	*B*	SE	*P*	*B*	SE	*P*	*B*	SE	*P*	*B*	SE	*P*	*B*	SE	*P*
Denmaj	0	0	0.529	-0.006	0.009	0.497	-0.002	0.03	0.961	0.006	0.006	0.314	-0.016	0.016	0.315	-0.074	0.042	0.079	0.014	0.009	0.12
Denmin	0	0	0.936	0.008	0.008	0.285	0.01	0.026	0.71	-0.002	0.005	0.709	-0.01	0.014	0.468	0.04	0.036	0.269	0	0.008	0.954
Lularb	0	0.001	0.816	-0.048	0.015	**<0.01**	0.042	0.053	0.434	-0.005	0.011	0.619	0.02	0.028	0.472	0.004	0.072	0.952	0.03	0.016	0.061
Sylmel	-0.002	0.001	**<0.01**	0.012	0.016	0.487	0.094	0.058	0.104	-0.003	0.011	0.807	0.028	0.03	0.351	-0.119	0.079	0.133	-0.005	0.017	0.793
Phyibe	0	0	0.277	0.023	0.01	**<0.05**	0.142	0.036	**<0.001**	-0.005	0.007	0.474	0.023	0.019	0.227	0.002	0.049	0.963	0.004	0.011	0.73
Parcae	0.001	0.001	0.079	-0.022	0.019	0.249	0.038	0.066	0.565	0.008	0.013	0.543	0.015	0.035	0.676	0.076	0.091	0.403	-0.018	0.02	0.374
Parmaj	0	0	0.439	0.01	0.011	0.361	-0.052	0.04	0.193	-0.009	0.008	0.25	-0.01	0.021	0.62	0.001	0.054	0.991	-0.021	0.012	0.086
Siteur	0	0	0.537	0.009	0.011	0.419	0.062	0.039	0.116	-0.002	0.008	0.804	-0.019	0.021	0.35	0.011	0.054	0.837	-0.007	0.012	0.526
Cerbra	0.001	0.001	0.354	0.005	0.014	0.718	-0.029	0.05	0.562	-0.013	0.01	0.206	0	0.026	0.99	-0.139	0.068	**<0.05**	0.041	0.015	**<0.01**
Fricoe	-0.002	0.001	0.062	-0.057	0.023	**<0.05**	0.195	0.081	**<0.05**	-0.005	0.016	0.75	0.01	0.042	0.806	0.112	0.111	0.316	-0.018	0.024	0.458
Embcal	-0.001	0.001	0.196	-0.061	0.017	**<0.001**	0.055	0.059	0.353	-0.009	0.012	0.465	-0.042	0.031	0.176	-0.016	0.081	0.848	0.019	0.018	0.289

We did not found any association between bird species and **cork removal** or **DBH**. Sardinian warbler *Sylvia melanocephala* is negatively related with **altitude**. Regarding vegetation features, **vegetation density** was negatively related with wood lark *Lullula arborea*, chaffinch *Fringilla coelebs* and corn bunting *Emberiza calandra* and positively with iberian chiffchaff *Phylloscopus ibericus*. **Woody richness** was positively related with *Fringilla coelebs* and *Phylloscopus ibericus*. The short-toed tree-creeper *Certhia brachydactyla* was positively related with ***C. undatus*** and negatively with ***C. florentinus***.

4.4. One-Way ANOVA

In order to evaluate if there were any significant differences in bird guilds and environmental variables between areas we used one-Way ANOVA. Results are presented in Table 3 and Table 4, respectively.

Table 3 – One-way ANOVA, density of bird guilds per area (averages and standard deviation) according to each area (C - Companhia das Lezírias, G - Serra de Grândola, M - Serra de Monfurado and R - Romeu) and results with significant differences performed with the Tukey HSD test.

Areas	**Forest**	***Montado* specialist**	**Open area**	**Shrub**
C (n=30)	6.0±2.3	0.5±0.7	1.5±1.5	2.5±2.0
G (n=30)	3.4±1.0	0.9±0.6	0.7±0.9	1.1±1.0
M (n=30)	7.7±3.4	0.9±0.7	2.8±2.2	2.2±2.1
R (n=27)	4.4±1.2	0.4±0.5	0.2±0.4	1.9±0.9
F	21.07	5.21	18.96	4.31
P	<0.001	<0.01	<0.001	<0.01
		Tukey HSD test		
C x G	<0.001	<0.05	-	<0.01
C x M	<0.05	<0.05	<0.01	-
C x R	<0.05	-	<0.01	-
G x M	<0.001	-	<0.001	<0.05
G x R	-	<0.05	-	-
M x R	<0.001	<0.05	<0.001	-

There are significant differences among the four areas and bird guilds. Serra de Monfurado is the area with the highest densities in all bird guilds while the lower ones are shared between Serra de Grândola and Romeu. Relatively to **open area** species,

there were no significant differences between Companhia das Lezírias and Serra de Grândola. Serra de Monfurado and Companhia das Lezírias showed no differences in **shrub** species. **Cork oak specialists** and **shrub** species are similar in Companhia das Lezírias and Romeu. There were no differences between Serra de Grândola and Serra de Monfurado concerning **cork oak specialist** species and this guild is the only one that is significantly different between Serra de Grândola and Romeu. Finally, **shrub** species showed no differences between Serra de Monfurado and Romeu.

Table 4 - One-way ANOVA of environmental variables (averages and standard deviation) according to each area (C - Companhia das Lezírias, G - Serra de Grândola, M - Serra de Monfurado and R - Romeu) and results with significant differences performed with the Tukey HSD test.

Areas	**Altitude**	**Vegetation density**	**Woody richness**	**DBH**	**Cork removal**	***C. florentinus***	***C. undatus***
C (n=30)	32.3±8.2	11.9±4.5	3.9±1.2	39.5±8.2	6.13±2.5	2.1±1.3	5.0±4.1
G (n=30)	205.8±43.6	16.3±4.9	2.1±0.6	35.3±5.8	5.1±3.3	2.1±1.0	7.4±4.4
M (n=30)	294.3±52.9	15.2±5.0	4.8±1.5	33.2±5.7	5.2±1.9	0.5±0.7	10.5±4.6
R (n=27)	454.0±91.1	15.4±4.9	2.2±0.4	39.0±7.4	6.9±2.6	0.1±0.2	3.0±2.4
F	282.58	4.63	52.75	5.84	2.81	36.94	18.43
P	<0.001	<0.01	<0.001	0.001	0.043	<0.001	<0.001
			Tukey HSD test				
C x G	<0.001	<0.01	<0.001	-	-	-	-
C x M	<0.001	<0.05	<0.01	<0.01	-	<0.001	<0.001
C x R	<0.001	<0.05	<0.001	-	-	<0.001	-
G x M	<0.001	-	<0.001	-	-	<0.001	<0.05
G x R	<0.001	-	-	-	-	<0.001	<0.01
M x R	<0.001	-	<0.001	<0.01	-	-	<0.001

The average age of **cork removal** was similar between all areas unlike **altitude** that was significantly different. Relatively to vegetation features, Serra de Grândola and Romeu are more similar in **woody richness** and **vegetation density**, while Serra de Monfurado shows no differences in **vegetation density** when compared with Serra de Grândola and Romeu. Trunk diameter at breast height (**DBH**) is significant different across the four areas. Relatively to the insect ***C. florentinus***, there were no differences between Companhia das Lezírias - Serra de Grândola and between Serra de Monfurado - Romeu; for ***C. undatus*** no differences were detected between Companhia das Lezírias - Serra Grândola and Companhia das Lezírias - Romeu.

5. Discussion

The higher species richness value of breeding bird communities in the studied cork oak areas was detected in Serra de Monfurado and the lower in Serra de Grândola. Nevertheless, in these areas the cork oak specialists occurred in higher densities (see Table 3).

Several authors (*e.g.* Blondel & Aronson, 1999; Díaz *et al.*, 2003; Harrop, 2007) suggested that the heterogeneous pattern of wooded matrix with open areas, scattered woodlands and undisturbed patches of Mediterranean forest and scrublands, a trait of the '*montado'* landscape, contribute to the highest richness in breeding birds in the Iberian Peninsula (*e.g.* Tellería, 2001). Our results are consistent with these findings, especially in Companhia das Lezírias and Serra de Monfurado where the woody richness is higher, as they encompass the highest densities in forest, open area and shrub species. Cork oak forested areas with lower shrubby understory are good habitats for open area species, while species like iberian chiffchaff *Phylloscopus ibericus*, blackcap *Sylvia atricapilla*, short-toed tree-creeper *Certhia brachydactyla* and nuthatch *Sitta europaea* occur mainly in sites with high and closed shrubs. Moreover, our results show that *Phylloscopus ibericus* seem to depend on patches of dense vegetation (Almeida & Granadeiro, 2000), while chaffinch *Fringilla coelebs*, wood lark *Lullula arborea* and corn bunting *Emberiza calandra*, species that need open ground to search for food (Almeida & Granadeiro, 2000), depend at least on the existence of clear cuts in the forested matrix. Serra de Monfurado is the best example, between the study areas, of the benefits of the spatial heterogeneity of montados which reflects the heterogeneity inside the bird community as this area encompasses the highest densities in all bird guilds.

The woody richness reflected the presence of a second or more species of shrub or tree, which results in greater woody diversity areas that can benefit landowners, bringing other products such as timber, resin, herbs, etc. In what bird diversity is concerned, a higher number of woody species could provide more feeding or nesting sites for birds and eventually reduce the insect pests (*e.g.* Pereira *et al.*, 2012). Companhia das Lezírias and Serra de Monfurado were the areas with higher densities in woody richness and consequently with higher densities in forest and shrub birds. Our results also showed that only *Fringilla coelebs* and *Phylloscopus ibericus* had a positive relationship with this type of areas.

In order to evaluate if altitude is an important factor of species distribution in *montado*, we survey cork oak stands across an altitude gradient between the 17 and 590 m. The only association between species and altitude, with statistical meaning, was a negative relation between Sardinian warbler *Sylvia melanocephala* and altitude. Although this species had a wide distribution across all country, it is clearly more abundant in the south and in areas of medium and low altitude (*e.g.* Equipa Atlas, 2008). Besides that, *Sylvia melanocephala* is a typically Mediterranean species (Hagemeijer & Blair, 1997) so its appearance will be less noted in areas of higher altitudes and with lower temperatures like Romeu. Based on the target species/groups selected (mainly the forest and cork oak specialists) and in the altitude range surveyed, our results suggest that altitude is not a key factor for bird species distribution in *montado*.

Companhia das Lezírias and Romeu share the relation between the density of cork oak specialists and the occurrence of *C. undatus*, which in this case is lower than the other areas. The CCA results (Fig. 2) also showed that cork oak specialists are negatively correlated with *C. florentinus*. In other words, where this insect pest appears more frequently the densities of cork oak specialists decrease. In areas where these birds have higher densities, *C. undatus* also appears more frequently. Since *C. florentinus* is an insect species that occurs preferentially in fragmented areas of montados whereas *C. undatus* prefers dense montados (Ferreira & Ferreira, 1991) therefore the relation between the forest bird species *Certhia brachydactyla* is expected to be positive with the last one. It is necessary to focus conservation efforts through the implementation of good management practices on the fragmented areas of montados since these favors the outbreak of the pest insect *C. florentinus,* which can accelerate the degradation of cork oak trees.

6. References

Almeida J (1992) Alguns aspectos dos efeitos do maneio dos montados de sobro Quercus suber na avifauna nidificante. Airo 3: 69-74

Almeida J, Granadeiro JP (2000) Seasonal variation of foraging niches in a guild of passerine birds in a cork-oak woodland. Ardea 88: 243-252

Bibby CJ, Burgess ND, Hill DA, Mustoe S (2000) Bird Census Techniques, Second Edition edn. London: Academic Press.

Blondel J, Aronson J (1999) Biology and Wildlife of the Mediterranean Region: Oxford University Press.

Bugalho M, Plieninger T, Aronson J, Ellatifi M, Crespo DG (2009) Open Woodlands: A Diversity of Uses (and Overuses). In Cork Oak Woodlands on the Edge, 33-47, p 315. London: Island Press

Correia TP (1993) Threatened landscape in Alentejo, Portugal: the 'montado' and other 'agro-silvo-pastoral' systems. Landscape and Urban Planning 24: 43-48

Costa A, Pereira H (2007) Montados e sobreirais: uma espécie, duas perspectivas. In Os Montados, muito para além das árvores, Silva JS (ed), pp 17-37. Lisboa: LPN, Público Comunicação Social SA, Fundação Luso-Americana para o Desenvolvimento

DGRF. (2007) Inventário Florestal Nacional 2005/06. Direcção Geral dos Recursos Florestais, Lisboa.

Díaz L (2006) Influences of forest type and forest structure on bird communities in oak and pine woodlands in Spain. Forest Ecology and Management 223: 54-65

Díaz M, Campos P, Pulido FJ (1997) The Spanish dehesas: a diversity in land-use and wildlife. In Farming and Birds in Europe. The Common Agricultural Policy and its

Implications for Bird Conservation., Pain DJ, Pienkowski, M.W. (ed), pp 178-209. London: Academic Press

Díaz M, Pulido FJ, Marañón T (2003) Diversidad biológica y sostenibilidad ecológica y económica de los sistemas adehesados. Ecossistemas XII

Equipa Atlas (2008) Atlas das Aves Nidificantes em Portugal (1999-2005), Lisboa: Assírio & Alvim.

Ferreira C, Ferreira GWS (1991) Pragas das folhosas: guia de campo: Direcção Geral de Planeamento e Agricultura.

Gil-Tena A, Saura S, Brotons L (2007) Effects of forest composition and structure on bird species richness in a Mediterranean context: Implications for forest ecosystem management. Forest Ecology and Management 242: 470-476

Godinho C, Rabaça J, Segurado P (2010) Breeding bird assemblages in riparian galleries of the Guadiana River basin (Portugal): the effect of spatial structure and habitat variables. Ecol Res 25: 283-294

Godinho C, Rabaça JE (2011) Birds like it Corky: the influence of habitat features and management of 'montados' in breeding bird communities. Agroforestry Systems 82: 138-195

Hagemeijer EJM, Blair MJ (1997) The EBCC Atlas of European Breeding Birds: Their Distribution and Abundance, London: T & A D Poyser.

Harrop SR (2007) Traditional agricultural landscapes as protected areas in international law and policy. Agriculture, Ecosystems & Environment 121: 296-307

Hoogeveen Y, Petersen J-E, Balazs K, Higuero I. (2004) High Nature Value Farmland – Characteristics, Trends and Policy Challenges. In Report E (ed.). Agency, E.E, Vol. No 1.

IBM Corp. (2012) IBM SPSS Statistics for Windows, Version 21.0, Armonk, NY: IBM Corp.

Leal AI, Correia RA, Granadeiro JP, Palmeirim JM (2011) Impact of cork extraction on birds: Relevance for conservation of Mediterranean biodiversity. Biological Conservation 144: 1655-1662

Olea L, Miguel-Ayanz AS (2006) The Spanish dehesa. A traditional Mediterranean silvopastoral system linking production and nature conservation. 21st General Meeting of the European Grassland Federation

Pereira P, Godinho C, Roque I, Marques A, Branco M, Rabaça J (2012) Time to rethink the management intensity in a Mediterranean oak woodland: the response of insectivorous birds and leaf-chewing defoliators as key groups in the forest ecosystem. Annals of Forest Science: 1-8

Pinto-Correia T, Ribeiro N, Sá-Sousa P (2011) Introducing the montado, the cork and holm oak agroforestry system of Southern Portugal. Agroforestry Systems 82: 99-104

Plieninger T (2007) Compatibility of livestock grazing with stand regeneration in Mediterranean holm oak parklands. Journal for Nature Conservation 15: 1-9

Rabaça JE (1990) The influence of shrubby understory in breeding bird communities of cork oak (Quercus suber) woodlands in Portugal. Portugaliae Zoologica 1: 6

Rodewald AD, Yahner RH (2001) Influence of landscape composition on avian community structure and associated mechanisms, Vol. 82, Washington, DC, ETATS-UNIS: Ecological Society of America.

Scarascia-Mugnozza G, Oswald H, Piussi P, Radoglou K (2000) Forests of the Mediterranean region: gaps in knowledge and research needs. Forest Ecology and Management 132: 97-109

Smilauer P, ter Braak CJF (2002) CANOCO reference manual on CanoDraw for Windows User's guide: Software for Canonical Community Ordination (version 4.5): Microcomputer Power, Ithaca, NY.

Tabachnick BG, Fidell LS (2001) Using multivariate statistics, Boston: Allyn and Bacon.

Tellería JL (2001) Passerine bird communities of iberian dehesas: a review. Animal Biodiversity and Conservation 24: 67

Telleria JT, Baquero R, Santos T (2003) Effects of forest fragmentation on European birds: implications of regional differences in species richness. Journal of Biogeography 30: 621-628

ter Braak CJF (1986) Canonical Correspondence Analysis: A New Eigenvector Technique for Multivariate Direct Gradient Analysis. Ecology 67: 1167-1179

Titeux N, Dufrêne M, Jacob JP, Paquay M, Defourny P (2004) Multivariate analysis of a fine-scale breeding bird atlas using a geographical information system and partial canonical correspondence analysis: environmental and spatial effects. Journal of Biogeography 31: 1841-1856

Zar JH (1999) Biostatistical Analysis, Fourth Edition edn. New Jersey: Prentice Hall.

7. Appendix

Table 5 – List of analyzed species, common and scientific names (taxonomic order), code (based on scientific names), number of sampling sites were the specie was detected (*N*), area were the species was detected (C - Companhia das Lezírias, G - Serra de Grândola, M - Serra de Monfurado and R - Romeu) and habitat specialization

Species		Code	*N* Area	Habitat specialization
Common name	Scientific name			
Hoopoe	*Upupa epops*	Upuepo	11 C, G, M	Open Area
Great Spotted Woodpecker	*Dendrocopos major*	Denmaj	27 C, G, M, R	Forest
Lesser Spotted Woodpecker	*Dendrocopos minor*	Denmin	12 C, G, M	Cork oak specialist
Theklae Lark	*Galerida theklae*	Galthe	9 G, M, R	Open Area
Wood Lark	*Lullula arborea*	Lularb	47 C, G, M, R	Forest
Wren	*Troglodytes troglodytes*	Trotro	51 C, G, M, R	Shrub
European Robin	*Erithacus rubecula*	Erirub	4 R	Forest
Common Nightingale	*Luscinia megarhynchos*	Lusmeg	60 C, G, M, R	Shrub
Redstart	*Phoenicurus phoenicurus*	Phopho	7 G, M, R	Cork oak specialist
Common Stonechat	*Saxicola torquata*	Saxtor	13 C, G, M	Open Area
Common Blackbird	*Turdus merula*	Turmer	55 C, G, M, R	Forest
Zitting Cisticola	*Cisticola juncidis*	Cisjun	6 C, G	Open Area
Melodious Warbler	*Hippolais polyglotta*	Hippol	8 C, M	Shrub
Blackcap	*Sylvia atricapilla*	Sylatr	15 C, M, R	Forest
Dartford Warbler	*Sylvia undata*	Sylund	2 C, R	Shrub

Subalpine Warbler	*Sylvia cantillans*	Sylcan	5 R	Shrub
Sardinian Warbler	*Sylvia melanocephala*	Sylmel	55 C, G, M, R	Shrub
Western Bonelli's Warbler	*Phylloscopus bonelli*	Phybon	3 C	Forest
Iberian Chiffchaff	*Phylloscopus ibericus*	Phyibe	14 C, G, M	Forest
Long-tailed Tit	*Aegithalos caudatus*	Aegcau	4 C, R	Forest
Crested Tit	*Parus cristatus*	Parcri	15 C, G, M	Forest
Blue Tit	*Parus caeruleus*	Parcae	80 C, G, M, R	Forest
Great Tit	*Parus major*	Parmaj	45 C, G, M, R	Forest
Nuthatch	*Sitta europaea*	Siteur	50 C, G, M, R	Cork oak specialist
Short-toed Tree-creeper	*Certhia brachydactyla*	Cerbra	47 C, G, M, R	Forest
Woodchat Shrike	*Lanius senator*	Lansen	6 M	Open Area
House Sparrow	*Passer domesticus*	Pasdom	5 C, M, R	Open Area
Tree Sparrow	*Passer montanus*	Pasmon	4 C, M	Open Area
Rock Sparrow	*Petronia petronia*	Petpet	5 C, G, M, R	Cork oak specialist
Chaffinch	*Fringilla coelebs*	Fricoe	80 C, G, M, R	Forest
European Serin	*Serinus serinus*	Serser	41 C, G, M, R	Forest
European Greenfinch	*Carduelis chloris*	Carchl	25 C, G, M, R	Forest
Goldfinch	*Carduelis carduelis*	Carcar	25 C, G, M, R	Open Area
Eurasian Linnet	*Carduelis cannabina*	Carcan	4 M	Open Area
Hawfinch	*Coccothraustes*	Coccoc	3	Forest

	coccothraustes		C, M	
Cirl Bunting	*Emberiza cirlus*	Embcir	9 C, G, M	Open Area
Rock Bunting	*Emberiza cia*	Embcia	2 R	Shrub
Corn Bunting	*Emberiza calandra*	Embcal	32 C, G, M	Open Area

Table 6 - Groups of environmental variables recorded at each one of the sampling stations

Environmental variables
Geographical location (coordinates)
Altitude (m)
Vegetation features
Number of dead trees (n)
Vegetation cover with three classes of height (<0.5, 0.5-2, 2-8 m) and five classes of density (0%, 0-15%, 15-30%, 30-60%, 60-100%)
Dominant plant species (*Quercus suber*, *Q, rotundifolia*, *Pinus pinaster*, *Cistus ladanifer*, *Rubus* sp.,*Ulex* sp.)
Management practices
Trunk diameter at breast height (DBH; cm)
Year of the last cork removal
Sanitary status
Presence/absence of *Biscogniauxia mediterranea*
Presence/absence of *Coroebus florentinus*
Presence/absence of *Coroebus undatus*
Presence/absence of bark beetles (Platypodidae)
Presence/absence of cerambycids (Cerambycidae)

G. CONSIDERAÇÕES FINAIS

Os resultados do nosso estudo corroboram a elevada diversidade avifaunística associada aos montados, demonstrando que locais de maior riqueza lenhosa contribuem para a ocorrência de uma maior diversidade de espécies por guilda. A diversidade de espécies lenhosas beneficia não só as aves, mas também os proprietários, uma vez que permite a exploração de outros recursos associados à floresta. Conciliando assim a sustentabilidade económica do montado e a conservação da vida selvagem.

Um dos objectivos deste estudo foi compreender a influência da altitude para a comunidade de aves. Os nossos resultados não demonstram a existência de uma relação significativa com esta variável, não sendo por isso determinante para a distribuição das aves na área de estudo.

Finalmente, em áreas onde a presença de *Coroebus florentinus* é menor, as aves especialistas do sobreiro aparecem em maiores densidades, e portanto podemos considera-los como bioindicadores de montados bem preservados.

H. REFERÊNCIAS BIBLIOGRÁFICAS

Almeida J (1992) Alguns aspectos dos efeitos do maneio dos montados de sobro *Quercus suber* na avifauna nidificante. *Airo* **3:** 69-74

Almeida J, Granadeiro JP (2000) Seasonal variation of foraging niches in a guild of passerine birds in a cork-oak woodland. *Ardea* **88:** 243-252

Bibby CJ, Burgess ND, Hill DA, Mustoe S (2000) *Bird Census Techniques*, Second Edition edn. London: Academic Press.

Blondel J, Aronson J (1999) *Biology and Wildlife of the Mediterranean Region*: Oxford University Press.

Bugalho M, Plieninger T, Aronson J, Ellatifi M, Crespo DG (2009) Open Woodlands: A Diversity of Uses (and Overuses). In *Cork Oak Woodlands on the Edge*, 33-47, p 315. London: Island Press

Correia TP (1993) Threatened landscape in Alentejo, Portugal: the 'montado' and other 'agro-silvo-pastoral' systems. *Landscape and Urban Planning* **24:** 43-48

Costa A, Pereira H (2007) Montados e sobreirais: uma espécie, duas perspectivas In *OS MONTADOS - Muito para além das árvores* Vol. 3, 17-37, p 247. Lisboa: Fundação Luso-Americana para o Desenvolvimento

DGRF. (2007) Inventário Florestal Nacional 2005/06. Direcção Geral dos Recursos Florestais, Lisboa.

Díaz L (2006) Influences of forest type and forest structure on bird communities in oak and pine woodlands in Spain. *Forest Ecology and Management* **223:** 54-65

Díaz M, Campos P, Pulido FJ (1997) The Spanish dehesas: a diversity in land-use and wildlife. In *Farming and Birds in Europe. The Common Agricultural Policy and its*

Implications for Bird Conservation., Pain DJ, Pienkowski, M.W. (ed), pp 178-209. London: Academic Press

Díaz M, Pulido FJ, Marañón T (2003) Diversidad biológica y sostenibilidad ecológica y económica de los sistemas adehesados. *Ecossistemas* **XII**

Equipa Atlas (2008) *Atlas das Aves Nidificantes em Portugal (1999-2005),* Lisboa: Assírio & Alvim.

Ferreira C, Ferreira GWS (1991) *Pragas das folhosas: guia de campo*: Direcçao Geral de Planeamento e Agricultura.

Gil-Tena A, Saura S, Brotons L (2007) Effects of forest composition and structure on bird species richness in a Mediterranean context: Implications for forest ecosystem management. *Forest Ecology and Management* **242:** 470-476

Godinho C, Rabaça JE (2011) Birds like it Corky: the influence of habitat features and management of 'montados' in breeding bird communities. *Agroforestry Systems* **82:** 138-195

Harrop SR (2007) Traditional agricultural landscapes as protected areas in international law and policy. *Agriculture, Ecosystems & Environment* **121:** 296-307

Hoogeveen Y, Petersen J-E, Balazs K, Higuero I. (2004) High Nature Value Farmland – Characteristics, Trends and Policy Challenges. In Report E (ed.). Agency, E.E, Vol. No 1.

Leal AI, Correia RA, Granadeiro JP, Palmeirim JM (2011) Impact of cork extraction on birds: Relevance for conservation of Mediterranean biodiversity. *Biological Conservation* **144:** 1655-1662

Natividade JV (1950) *Subericultura*, Lisboa: Direcção Geral dos Serviços Florestais e Aquícolas.

Olea L, Miguel-Ayanz AS (2006) The Spanish dehesa. A traditional Mediterranean silvopastoral system linking production and nature conservation. *21st General Meeting of the European Grassland Federation*

Pereira P, Godinho C, Roque I, Marques A, Branco M, Rabaça J (2012) Time to rethink the management intensity in a Mediterranean oak woodland: the response of insectivorous birds and leaf-chewing defoliators as key groups in the forest ecosystem. *Annals of Forest Science***:** 1-8

Pinto-Correia T, Ribeiro N, Sá-Sousa P (2011) Introducing the *montado*, the cork and holm oak agroforestry system of Southern Portugal. *Agroforestry Systems* **82:** 99-104

Plieninger T (2007) Compatibility of livestock grazing with stand regeneration in Mediterranean holm oak parklands. *Journal for Nature Conservation* **15:** 1-9

Rabaça JE (1990) The influence of shrubby understory in breeding bird communities of cork oak (*Quercus suber*) woodlands in Portugal. *Portugaliae Zoologica* **1:** 6

Rodewald AD, Yahner RH (2001) *Influence of landscape composition on avian community structure and associated mechanisms*, Vol. 82, Washington, DC, ETATS-UNIS: Ecological Society of America.

Scarascia-Mugnozza G, Oswald H, Piussi P, Radoglou K (2000) Forests of the Mediterranean region: gaps in knowledge and research needs. *Forest Ecology and Management* **132:** 97-109

Tellería JL (2001) Passerine bird communities of iberian dehesas: a review. *Animal Biodiversity and Conservation* **24:** 67

Telleria JT, Baquero R, Santos T (2003) Effects of forest fragmentation on European birds : implications of regional differences in species richness. *Journal of Biogeography* **30:** 621-628

ter Braak CJF (1986) Canonical Correspondence Analysis: A New Eigenvector Technique for Multivariate Direct Gradient Analysis. *Ecology* **67:** 1167-1179

Zar JH (1999) *Biostatistical Analysis*, Fourth Edition edn. New Jersey: Prentice Hall.