Agriculture, Ecosystems and Environment 269 (2019) 107–115

Contents lists available at ScienceDirect

Agriculture, Ecosystems and Environment

journal homepage: www.elsevier.com/locate/agee

Organic farming favours bird communities and their resilience to climate change in Mediterranean vineyards

Àlex Rollan[a,*], Antonio Hernández-Matías[a,b], Joan Real[a]

[a] Equip de Biologia de la Conservació, Departament de Biologia Evolutiva, Ecologia i Ciències Ambientals and Institut de la Recerca de la Biodiversitat (IRBIO), Facultat de Biologia, Universitat de Barcelona, Avinguda Diagonal, 645, 08028, Barcelona, Catalonia, Spain

[b] Departament de Ciències Ambientals, Facultat de Ciències, Universitat de Girona, Campus Montilivi, 17003, Girona, Catalonia, Spain

ARTICLE INFO

Keywords:
Vineyards
Organic farming
Herbaceous cover
Birds
Climate change

ABSTRACT

Farmland birds have suffered notable declines in Europe in recent decades, mainly due to agricultural intensification and climate change. Organic farming, which has been shown to enhance biodiversity, is increasingly being put into practice in European vineyards. Nevertheless, no previous studies have reported significant positive responses in avian communities to organic practices. On the other hand, cover cropping is a common practice in both organic and conventional vineyards and is thought to have positive effects on bird communities and, particularly, on insectivorous species that may help control pests in agroecosystems. In this work, we studied bird communities in Mediterranean vineyards in Catalonia (NE Iberian Peninsula) in both the breeding and wintering seasons, and tested the effects of two common management options – organic vs. conventional farming and herbaceous cover vs. bare soil – on bird communities. In particular, we focused on (a) insectivorous birds that may help control pests and (b) avian species negatively affected by climatic warming whose population fluctuations may reflect the resilience of these bird communities to future climate change. Organic farming had a positive effect on vineyard bird communities and, specifically, increased species richness and overall bird abundance. This farming technique also positively affected the abundance of both insectivorous species and species whose populations are declining due to climate change. The presence of inter-row herbaceous cover between vines also had positive effects on bird community parameters, specifically in spring and in organic vineyards, when herbaceous cover favours species richness and the abundance of insectivorous species. However, further investigations are still needed to better understand the effects of different types of vegetation cover - i.e. plant origin and composition (e.g. sown vs. spontaneous vegetation) and proportion of vegetation cover (full vs. partial vegetation cover) - when employed as tools in wildlife conservation. This work provides useful information regarding bird conservation, which will help mitigate the effects of climate change on bird populations.

1. Introduction

Traditional agricultural landscapes harbour high levels of biodiversity that are negatively affected by agricultural intensification (Firbank et al., 2008; Henle et al., 2008; Norris, 2008). European farmland birds are known to be undergoing a serious decline, mainly due to changes occurring in agricultural systems such as landscape simplification, increased mechanization or increased fertilizer and pesticide use, amongst others (Donald et al., 2001; Guerrero et al., 2012; Gregory et al., 2005). To reverse this situation, agricultural policies are increasingly promoting ecologically oriented farming methods whose aims include preserving biodiversity and conserving natural resources (Pfiffner and Balmer, 2011). Organic farming has been shown to enhance biodiversity (Bengtsson et al., 2005; Fuller et al., 2005) and worldwide its surface area grew from 11 million ha in 1999 to 43.7 million ha in 2014 (Willer and Lernoud, 2016). Specifically, the surface area of organic vineyards in Europe increased from 87,577 ha in 2004 to 315,579 ha in 2014, and today over 80% of the world's organic vineyards are found in Europe; the countries with the largest surface areas of organic grape production are Spain, Italy and France, each with over 60,000 ha of organic vineyards (Willer and Lernoud, 2016).

However, despite the increase in organic grape production, few studies have dealt with the effects of organic farming on vineyard bird communities, and none have found any significant positive response in avian communities to these farming methods (Assandri et al., 2016, 2017a, 2017b; Macià et al., 2012; Puig-Montserrat et al., 2017).

* Corresponding author.
E-mail addresses: alexrollan@gmail.com (À. Rollan), ahmatias@gmail.com (A. Hernández-Matías), jreal@ub.edu (J. Real).

https://doi.org/10.1016/j.agee.2018.09.029
Received 1 December 2017; Received in revised form 21 September 2018; Accepted 24 September 2018
Available online 02 October 2018
0167-8809/

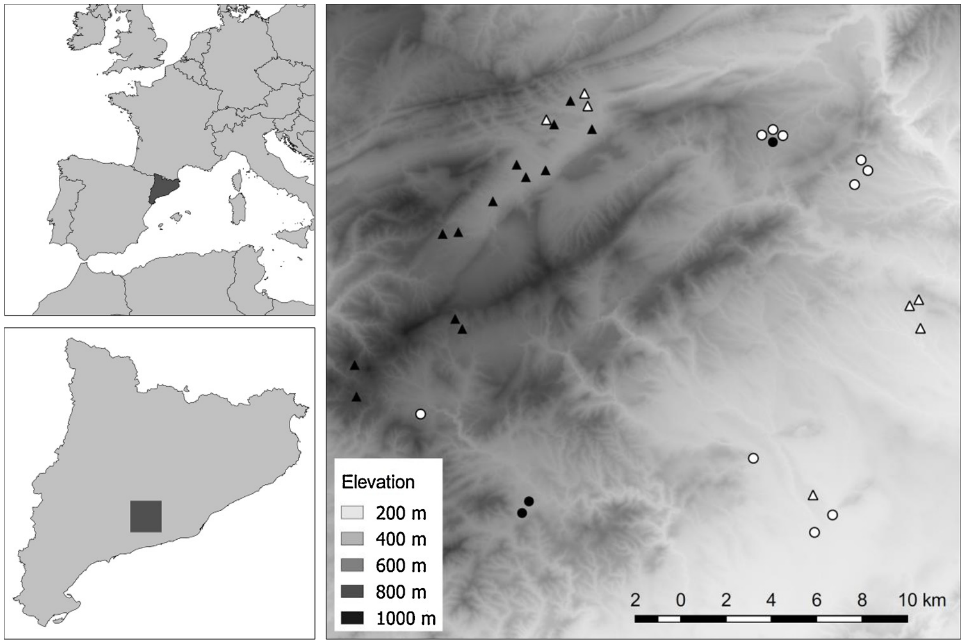

Fig. 1. Location of the study area in Catalonia and the 33 transects in the study area. Organic with herbaceous cover (white circles), organic with bare soil (white triangles), conventional with herbaceous cover (black circles) and conventional with bare soil (black triangles) farming transects are shown.

Interestingly, Duarte et al. (2014) studied birds in three vineyards subjected to different crop management schemes. In one vineyard, herbaceous cover was managed to prevent excessive competition with the main crop by mechanical mowing whereas synthetic herbicides were applied in the second one. In the third vineyard, the soil was tilled to maintain bare soil. Despite the study's limitations of low replication and uncertified organic vineyards, they found that overall species richness and diversity was higher in vineyards where herbaceous cover underwent mechanical mowing, similar to organic farming, compared to those where synthetic herbicides were applied. It also showed that vineyards with bare soil had the lowest bird diversity, abundance and species richness of the three studied vineyards, which suggests that the implementation of herbaceous cover may be a viable technique in habitat management for conservation and production purposes.

Insectivorous birds are known to help control pests in agroecosystems (Barbaro et al., 2016; Pfiffner and Balmer, 2011). Duarte et al. (2014) also found a greater abundance of insectivorous passerine birds where the herbaceous cover underwent mechanical mowing, although it is not clear if this was due to the presence of herbaceous cover or a less intensive use of pesticides. Other authors (Arlettaz et al., 2012; Barbaro et al., 2016; Guyot et al., 2017) have found evidence that herbaceous cover would have a positive effect on bird communities and, in particular, on insectivorous species. A study by Barbaro et al. (2016) reported that the total abundance of insectivorous birds was 15% higher in vineyards with full grass cover than in vineyards with partial cover alternating with bare ground. Arlettaz et al. (2012) showed that the proportion of ground vegetation cover influenced the pattern of microhabitat selection by woodlarks, mostly insectivorous during the breeding season, with an optimum around 55% at the foraging patch scale. Guyot et al., (2017) reported that birds showed a marked preference for plots with vegetated ground in winter but chose plots with intermediate vegetation cover in spring and summer. According to these authors, such season-specific preferences might be related to species-specific life histories, that is, more insectivores, ground-foraging species are present during the breeding season than in winter, when granivorous species predominate (Guyot et al., 2017). This might also be associated with some granivorous winter birds diet changing to an insectivorous diet in the breeding season, since a protein-rich food is essential also for chick growth of granivorous bird species (Guyot et al., 2017).

Furthermore, climate change is having a significant – both negative and positive – effect on bird populations (Devictor et al., 2012; Gregory et al., 2009; Scheffers et al., 2016). Based on a combination of observed population trends in 20 European countries over 26 years and climatic envelope models, Gregory et al. (2009) grouped 122 common bird species into those whose potential range is projected to increase or to decrease. According to this analysis, the number of bird species whose populations will be negatively affected by climatic change is three times greater than those that will be positively affected (Gregory et al., 2009). However, the influence of land cover on species' responses to climate change will probably differ depending on habitat type and composition (Jarzyna et al., 2016). Therefore, an understanding of these interactions will be vital for managing habitats appropriately if the negative impact of climate change on biodiversity is to be reduced by the implementation of adaptation strategies (Oliver and Morecroft, 2014).

Thus, in the current context of global climate change, knowledge of vineyard management practices are highly relevant factors when attempting to provide guidance on how to enhance bird conservation and abundance of insectivorous birds that may help control pests, and how to mitigate the potential effects of climate change on bird populations. Here, we focus on bird communities in Mediterranean vineyards in Catalonia (NE Iberian Peninsula) in both the breeding and wintering seasons and test the effects of two common management options – organic vs. conventional farming and herbaceous cover vs. bare soil – on bird communities and, in particular, on insectivorous birds and the birds that are negatively affected by climatic change according to Gregory et al. (2009).

2. Methods

2.1. Study area

This study was conducted in the wine appellation of origin Penedès (Fig. 1) in Catalonia. The main land uses in the study area are forests (34% of the whole area) dominated by Aleppo pine (*Pinus halepensis*) and holm oak (*Quercus ilex*) woodland, scrubland (17%), vineyards (15%), cereal crops (14%) and urban land and infrastructures (9%). Certified organic agricultural holdings represent about 24% of the

24,248 ha included in the appellation of origin (Godia, 2015)

The area has a Mediterranean climate with an average annual temperature of about 15 °C and an average annual rainfall of around 550 mm, mainly in spring and autumn (Ramos et al., 2008).

2.2. Bird monitoring and experimental design

To survey birds in vineyards, we set up 200-m-long linear transects (see Assandri et al., 2016, 2017b) in 33 vineyards (192–845 m a.s.l.) in the study area, 17 of which were organically farmed (10 with inter-row herbaceous cover between vines and 7 with bare soil) and 16 conventionally managed (3 with herbaceous cover and 13 with bare soil; see Fig. 1). Each transect in which bird monitoring was performed was 100-m wide; observers walked along the centre of the transect, thereby monitoring a 50-m strip on each side (see Barbaro et al., 2016; Guyot et al., 2017). All transects were located in vineyard patches with a minimum size of 2 ha. To avoid double counts, a minimum distance of 300 m between neighbouring transects was established (see Assandri et al., 2016, 2017b).

Censuses were performed twice during the breeding season (1–9 May; 2–9 June 2014) and twice in winter (5–14 January; 2–14 February 2015), between dawn and four hours after sunrise, without rain or wind. Surveys were walked slowly by the same observer (A.R.), who took 10–15 min to complete each one.

Only birds using the vineyards (perching, feeding on the ground or flying to capture insects) were recorded (as in Assandri et al., 2016, 2017b; Barbaro et al., 2016; Duarte et al., 2014); birds only identified by their song with no information on their use of the vineyards were not included in the counts. For all transects and for each season (spring and winter), we calculated four bird community parameters: species richness, overall bird abundance, abundance of insectivorous species, and abundance of species negatively affected by climatic change, according to Gregory et al. (2009). The abundance of insectivorous species was considered as dependent variable due to the natural pest control services provided by insectivorous birds (Barbaro et al., 2016; Pfiffner and Balmer, 2011). Likewise, the abundance of species negatively affected by climatic change is of great interest given the significant effects of climate change on bird populations (Devictor et al., 2012; Gregory et al., 2009; Scheffers et al., 2016).

The maximum number of individuals counted on the two censuses was retained as an estimate of relative bird abundance for each species, a methodology used in similar studies (Barbaro et al., 2016; Herrando et al., 2015; Macià et al., 2012; Pithon et al., 2016; Verhulst et al., 2004). Species were classified following Barbaro et al. (2016) and Del Hoyo et al. (2017) according to their diets in spring and winter: insectivorous, granivorous or frugivorous. As detailed by Gregory et al. (2009), species were also categorised as having populations that are either negatively or positively affected by climate change. Finally, bird abundances were pooled to obtain the abundance for all birds detected, insectivore species and species negatively affected by climatic change. Species richness refers to the total number of species encountered per transect during the two seasonal censuses.

2.3. Vineyard management, landscape and topographic variables

To evaluate the effect of vineyard management, organic farming and the presence of inter-row herbaceous cover between vines on bird community parameters, we took into account a variety of potential confounding landscape and topographic variables (Table 1) based on those used in previous studies (Assandri et al., 2016, 2017b; Concepción et al., 2008; Duarte et al., 2014; Pithon et al., 2016; Puig-Montserrat et al., 2017). We considered as organic only the vineyards officially certified by the Catalan Council of the Organic Production (CCPAE). Thus, organic vineyards were characterised by the non-use of synthetic fertilizers, fungicides, insecticides and herbicides. Inter-row herbaceous cover between vines may be sown, composed of black oats (*Avena strigosa*) and a mixture of leguminous species, or spontaneous cover, consisting of a complex weed community. Spontaneous cover was present in inter-rows, whereas sown herbaceous cover was only implemented in alternate inter-rows. All this information is provided for all the surveyed transects in Table A1 (Appendix A. Supplementary data). Herbaceous cover was managed by mechanical mowing or soil tillage in organically managed vineyards, and by herbicide application in conventionally managed vineyards.

Table 1
List of variables used to characterize transects. Landscape variables were obtained for an area delimited by a 200-m buffer zone around transects.

Variable name	Description
Management variables	
Organic farming (ORG)	Organic vs. conventional farming.
Herbaceous cover (HCO)	Presence of inter-row herbaceous cover between vines vs. bare soil.
Landscape variables	
Vineyards (VIN)	% cover of vineyards.
Arable and tree crops (CRO)	% cover of other types of farmland including arable land (mainly annual cereal crops) and tree crops (dry tree-crops such as olive and almonds and irrigated orchards).
Shrublands (SHR)	% cover of shrublands and grasslands.
Forests (FOR)	% cover of forests, including Mediterranean maquis and broad-leaved evergreen, deciduous and coniferous forests.
Urban areas (URB)	% cover of urban areas and infrastructures.
Patches (PAT)	Number of land cover patches.
Hedgerows (HED)	Length (m) of hedgerows
Topographic variables	
Altitude (ALT)	Altitude (m a.s.l.) of the central point of the transect.

Landscape variables were obtained for an area delimited by a 200-m buffer zone around transects using the fourth edition of the Land Cover Map of Catalonia (www.creaf.uab.es/mcsc/) and the software QGIS (QGIS Development Team, 2014). This buffer distance was considered adequate to account for the effect of landscape variables on birds' presence in the transects (Assandri et al., 2016, 2017b; Duarte et al., 2014). The original land-use categories were reclassified to obtain proportions of the following broader land-cover categories: (a) vineyards, (b) arable and tree crops, (c) shrublands and grasslands, (d) forests and (e) urban areas and infrastructures. Based on these land cover categories, we obtained the number of land cover patches. The length of hedgerows was measured using detailed aerial photographs (www.icgc.cat/).

2.4. Statistical analysis

First, we checked that there was no evidence of spatial autocorrelation in our data by running the Dispersion Indices analysis included in the *PASSaGE 2* software (Rosenberg and Anderson, 2011). Then, following the protocol for data exploration proposed by Zuur et al. (2010), all independent variables were examined before model building. We used Spearman's correlation coefficient to explore collinearity between variables, setting a restrictive threshold of ± 0.7 or greater to reject redundant variables from later models (Dormann et al., 2013). The proportion of forests showed a strong correlation ($|r| \geq 0.7$) with the proportion of vineyards and was consequently excluded from the models. In addition, since preliminary data exploration showed a weak effect of the proportion of arable and tree crops, shrublands and urban areas and infrastructures on most of the five community parameters, these proportions were also excluded from our final set of predictors in order to keep the least number of explanatory variables (Quinn and Keough, 2002). Predictors were visually examined for possible outliers and, since apparent outliers were not found, no data transformation was performed.

In order to test the effect of factors (organic farming and presence of

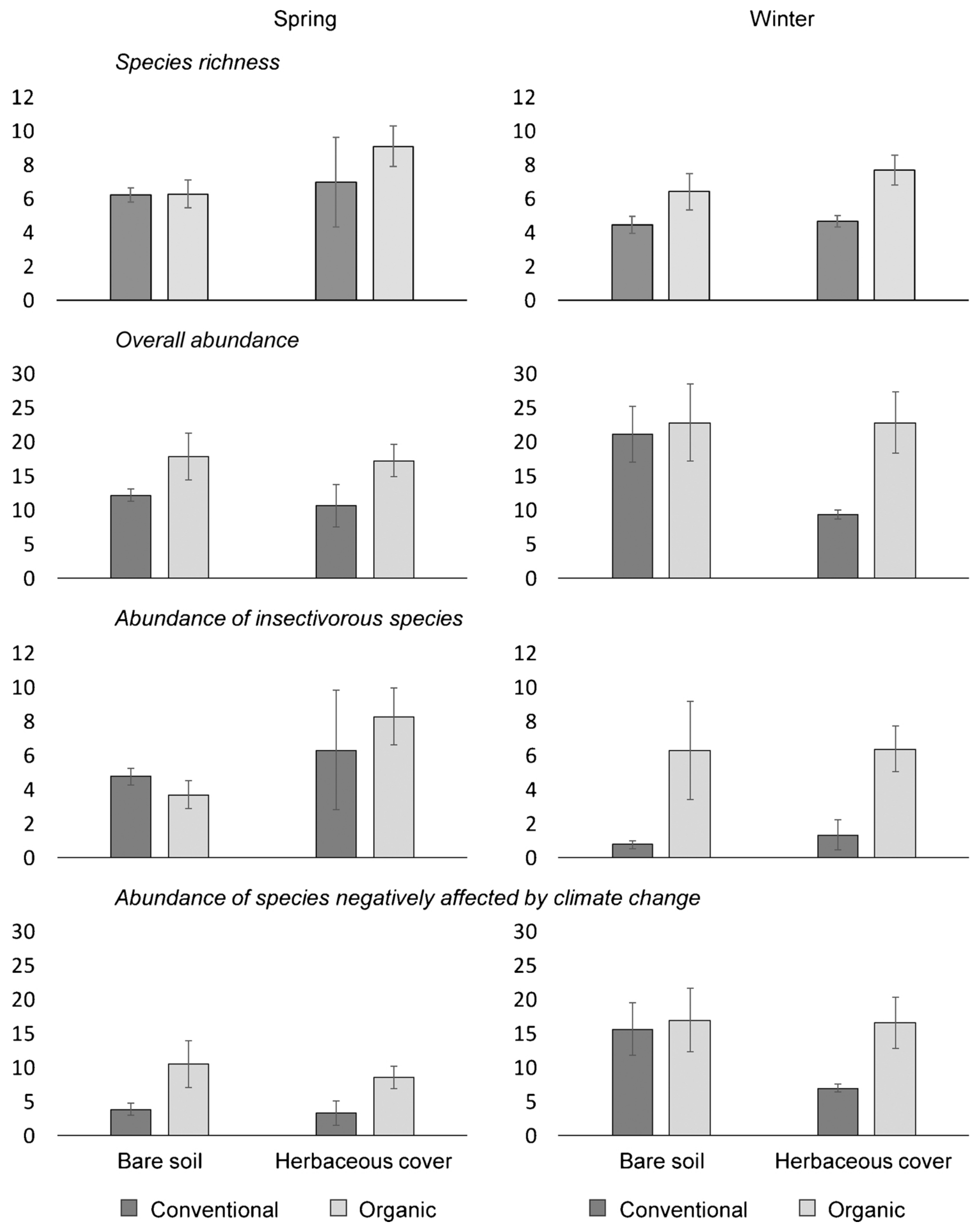

Fig. 2. Graphical representation of the effect of management variables on bird community parameters: species richness, overall bird abundance, abundance of insectivorous species and abundance of species negatively affected by climate change. Means and their standard errors are given.

inter-row herbaceous cover between vines) and covariates (landscape and topographic variables) on the dependent variables (species richness, overall bird abundance, the abundance of insectivorous, abundance of species negatively affected by climatic change), we used generalised linear models (GLMs) with a Poisson error distribution or, in case of overdispersion ($\varphi > 1.0$), a negative binomial distribution with a log-link function (Zuur et al., 2013). The Lagrange multiplier test (Greene, 2002) was used to estimate the optimal ancillary parameter (k) of each negative binomial distribution through an iterative process (Heck et al., 2012). Thus, a Poisson error distribution was used for species richness whereas a negative binomial distribution was used for overall bird abundance, the abundance of insectivorous and the abundance of species negatively affected by climatic change. Modelling was carried out using an information-theoretic approach (Burnham and Anderson, 2002) by running all possible models for each dependent variable and season. Interaction between management variables was included in the models suggested by preliminary graphical data exploration (see Fig. 2). As an exception, given that chaffinches accounted for 47.2% of the overall bird abundance in winter, we also modelled the effect of factors and covariates on the winter abundance of this species using a negative binomial distribution with a log-link function.

We then performed model-averaging across a 95%-confidence set of best-ranked models, i.e. those whose cumulative Akaike weight, acc wi, ≥ 0.95 (see Tables A2–A10 in Appendix A. Supplementary data), and obtained model-averaged coefficients, standard errors and relative variable importance for each explanatory variable using the full-model averaging option (Burnham and Anderson, 2002; Symonds and Moussalli, 2011). We considered that a variable had a significant effect on bird community parameters when the confidence intervals did not include zero. The statistical analyses were performed using SPSS 15.0 software package (IBM, USA).

Finally, since we did not consider the herbaceous cover origin (sown vs. spontaneous cover) in the GLMs analyses due to sample size limitations, we tested its effect on species richness and overall abundance by means of a Mann-Whitney U test (Fowler and Cohen, 1992), indicating mean parameter estimates and standard errors.

Table 2
Species list and characteristics. Following Gregory et al. (2009), species were classified into populations positively (P) or negatively (N) affected by climate change, and those not evaluated (NE). In accordance with Barbaro et al. (2016) and Del Hoyo et al. (2017), species were classified according to diet as insectivorous (I), granivorous (G) or frugivorous (F). The abundance of each species was derived from the maximum number of individuals in the two censuses.

Species	Impact by CC	Diet		Abundance	
		Spring	Winter	Spring	Winter
Alauda arvensis Skylark	N	I	G	4	1
Anthus campestris Tawny Pipit	P	I	–	1	–
Anthus pratensis Meadow Pipit	N	–	I	–	44
Carduelis cannabina Linnet	P	G	G	77	52
Carduelis carduelis Goldfinch	P	G	G	18	31
Carduelis chloris Greenfinch	N	G	G	11	8
Columba palumbus Wood Pigeon	N	G	–	47	–
Coturnix coturnix Quail	NE	G	–	3	–
Emberiza calandra Corn Bunting	NE	I	–	8	–
Emberiza cirlus Cirl Bunting	P	I	G	43	38
Erithacus rubecula Robin	N	–	I	–	1
Fringilla coelebs Chaffinch	N	I	G	2	327
Galerida cristata Crested Lark	P	I	G	23	12
Garrulus glandarius Jay	N	G	–	3	–
Hippolais polyglotta Melodious Warbler	P	I	–	5	–
Lanius senator Woodchat Shrike	P	I	–	6	–
Lullula arborea Woodlark	N	I	G	27	37
Motacilla alba White Wagtail	N	I	I	9	25
Muscicapa striata Spotted Flycatcher	N	I	–	1	–
Oenanthe oenanthe Northern Wheatear	N	I	–	1	–
Parus major Great Tit	N	I	I	9	2
Passer domesticus House Sparrow	N	G	–	10	–
Petronia petronia Rock Sparrow	N	G	G	2	1
Phoenicurus ochruros Black Redstart	N	I	I	5	43
Phylloscopus collybita Chiffchaff	N	–	I	–	1
Pica pica Magpie	N	G	–	8	–
Picus viridis Green Woodpecker	N	I	–	2	–
Saxicola rubetra Whinchat	N	I	–	9	–
Saxicola torquatus Stonechat	P	I	I	8	4
Serinus serinus Serin	P	G	G	75	44
Streptopelia decaocto Collared Dove	P	G	–	1	–
Sturnus vulgaris Common Starling	N	G	–	44	–
Sylvia atricapilla Blackcap	N	–	F	–	1
Sylvia melanocephala Sardinian Warbler	P	–	I	–	2
Turdus merula Blackbird	N	I	F	3	2
Turdus philomelos Song Thrush	N	–	F	–	2
Turdus viscivorus Mistle Thrush	N	I	F	23	15
Upupa epops Hoopoe	P	I	–	1	–

Table 3
Model averaged parameter estimates, standard errors and relative variable importances (RVI) of the 95% confidence set of best-ranked GLMs (with cumulative Akaike weights acc W_i, ≤0.95) explaining the effects of management, landscape and topographic variables on bird community parameters. Variables considered where ORG (organic vs. conventional farming), HCO (presence of inter-row herbaceous cover between vines vs. bare soil), VIN (% cover of vineyards), PAT (number of land cover patches), HED (length (m) of hedgerows) and ALT (altitude (m a.s.l.) of the central point of the transect). Variables in bold indicates those for which confidence intervals did not include zero.

Variable	Spring		Winter	
	β ± S.E.	RVI	β ± S.E.	RVI
Species richness				
Intercept	1.182 ± 0.255		2.221 ± 0.319	
ORG	0.023 ± 0.042	0.304	**0.140 ± 0.079**	**0.472**
HCO	**0.054 ± 0.048**	**0.328**	0.027 ± 0.038	0.281
ORG*HCO	**$5.4 \times 10^{-3} \pm 4.7 \times 10^{-3}$**	**0.017**	**$7.4 \times 10^{-3} \pm 5.3 \times 10^{-3}$**	**0.023**
VIN	**1.181 ± 0.290**	**0.841**	**0.121 ± 0.120**	**0.279**
PAT	**−0.008 ± 0.005**	**0.396**	**−0.017 ± 0.008**	**0.528**
HED	$-2.6 \times 10^{-6} \pm 9.0 \times 10^{-5}$	0.353	$8.0 \times 10^{-7} \pm 6.3 \times 10^{-5}$	0.243
ALT	$3.7 \times 10^{-5} \pm 8.2 \times 10^{-5}$	0.260	**$-1.1 \times 10^{-3} \pm 3.8 \times 10^{-4}$**	**0.783**
Overall abundance				
Intercept	1.900 ± 0.312		3.134 ± 0.332	
ORG	**0.150 ± 0.085**	**0.532**	0.080 ± 0.098	0.350
HCO	**−0.120 ± 0.083**	**0.452**	**−0.076 ± 0.073**	**0.292**
ORG*HCO	0.009 ± 0.011	0.043	**0.038 ± 0.016**	**0.045**
VIN	**1.123 ± 0.395**	**0.847**	**−0.271 ± 0.205**	**0.314**
PAT	**−0.006 ± 0.005**	**0.322**	−0.003 ± 0.008	0.292
HED	**$1.5 \times 10^{-4} \pm 9.9 \times 10^{-5}$**	**0.343**	$1.0 \times 10^{-5} \pm 1.1 \times 10^{-4}$	0.225
ALT	$-1.1 \times 10^{-4} \pm 1.5 \times 10^{-4}$	0.322	$-1.6 \times 10^{-4} \pm 2.4 \times 10^{-4}$	0.280
Abundance of insectivorous species				
Intercept	0.811 ± 0.497		0.286 ± 0.597	
ORG	0.025 ± 0.061	0.275	**2.033 ± 0.410**	**0.954**
HCO	**0.216 ± 0.136**	**0.507**	0.072 ± 0.114	0.339
ORG*HCO	**0.017 ± 0.015**	**0.030**	−0.022 ± 0.035	0.042
VIN	**1.243 ± 0.458**	**0.716**	−0.057 ± 0.251	0.232
PAT	**−0.029 ± 0.014**	**0.560**	−0.010 ± 0.011	0.277
HED	$2.7 \times 10^{-5} \pm 7.1 \times 10^{-5}$	0.204	**$-8.1 \times 10^{-4} \pm 3.8 \times 10^{-4}$**	**0.470**
ALT	**$5.3 \times 10^{-4} \pm 3.0 \times 10^{-4}$**	**0.433**	$-2.6 \times 10^{-4} \pm 3.3 \times 10^{-4}$	0.224
Abundance of species negatively affected by climatic change				
Intercept	2.979 ± 0.658		3.024 ± 0.416	
ORG	**0.201 ± 0.128**	**0.374**	0.087 ± 0.097	0.302
HCO	−0.094 ± 0.095	0.303	−0.040 ± 0.077	0.261
ORG*HCO	0.004 ± 0.009	0.014	**0.013 ± 0.007**	**0.017**
VIN	0.301 ± 0.303	0.288	**−0.640 ± 0.325**	**0.399**
PAT	**−0.034 ± 0.015**	**0.478**	0.001 ± 0.009	0.229
HED	**$3.1 \times 10^{-4} \pm 2.1 \times 10^{-4}$**	**0.366**	$2.9 \times 10^{-5} \pm 1.4 \times 10^{-4}$	0.235
ALT	**$-2.7 \times 10^{-3} \pm 7.7 \times 10^{-4}$**	**0.822**	$-1.4 \times 10^{-4} \pm 2.4 \times 10^{-4}$	0.231

3. Results

During the spring surveys, 489 individuals of 32 bird species were detected (Table 2), of which 20 (62.5%) were insectivorous and 19 (59.4%) were classified as being negatively affected by climatic change according to Gregory et al. (2009). The results for winter gave 693 individuals of 22 species (Table 2), of which eight (36.4%) were insectivorous and 14 (63.6%) could be negatively affected by climatic change.

According to the averaged models obtained for the four response variables in both spring and winter (Table 3), organic farming had a positive effect on species richness in winter, on overall bird abundance in spring, on the abundance of insectivorous species in winter, and on the abundance of species negatively affected by climatic change in spring, as is also shown in Fig. 2.

The presence of herbaceous cover had a positive effect on species richness in spring and on the abundance of insectivorous species according to averaged models (Table 3), as can be seen in Fig. 2. On the other hand, the presence of herbaceous cover had a negative effect on overall bird abundances in both spring and winter. In addition, the interaction between organic farming and the presence of herbaceous cover also had a positive effect on species richness in both spring and winter, on overall bird abundance in winter, on the abundance of insectivorous species in spring, and on the abundance of species negatively affected by climate change in winter, as shown in Fig. 2. Furthermore, in spring transects with spontaneous cover appeared to have more species (9.88 ± 1.11) and birds (17.63 ± 1.94) than transects with sown herbaceous cover (6.60 ± 2.02 and 12.80 ± 4.41 respectively), although no significant differences were found for species richness ($U_{Mann\text{-}Whitney} = 10.000$; $p = 0.142$) and overall abundance ($U_{Mann\text{-}Whitney} = 11.500$; $p = 0.212$). In winter, transects with spontaneous cover also had more species (7.88 ± 0.77) and birds (22.13 ± 4.66) than transects with sown herbaceous cover (5.60 ± 1.47 and 16.00 ± 6.98 respectively), although again no significant differences were found for species richness ($U_{Mann\text{-}Whitney} = 11.000$; $p = 0.182$) and overall abundance ($U_{Mann\text{-}Whitney} = 12.000$; $p = 0.239$).

The proportion of vineyard cover within a 200-m buffer zone around transects had a positive effect on most bird community parameters (Table 3), species richness in both spring and winter, on overall bird abundance and the abundance of insectivorous species. Nevertheless, it had the opposite (negative) effect on overall bird abundance and on the abundance of species negatively affected by climate change in winter.

On the other hand, the number of land cover patches within a 200-m buffer zone around transects had a negative effect on most bird community parameters (Table 3), on species richness in both spring and winter, and on overall bird abundance, on the abundance of insectivorous species and on the abundance of species negatively affected by climate change in spring.

The length of hedgerows within a 200-m buffer zone around transects only appeared to have a positive effect on overall bird abundance and the abundance of species negatively affected by climate change in spring, whereas it had the opposite (negative) effect on the abundance of insectivorous species in winter.

Altitude had a negative effect on species richness in winter and on the abundance of species negatively affected by climate change in spring. Altitude only had a positive effect on the abundance of insectivorous species in spring.

Finally, according to the average models obtained for the winter chaffinch abundance (Table 4), this species was negatively affected by the presence of herbaceous cover, the proportion of vineyard cover within a 200-m buffer zone around transects and the altitude. However, the interaction between organic farming and the presence of herbaceous cover had a positive effect on the winter abundance of this species.

4. Discussion

Our study showed that organic farming has significant effects on vineyard bird communities. As expected, given the results of previous studies (Bengtsson et al., 2005; Duarte et al., 2014; Fuller et al., 2005), we found that organic farming had a positive effect on bird species richness in winter, on overall bird abundance in spring, on the abundance of insectivorous species in winter, and on the abundance of species negatively affected by climate change in spring. Organic farming, which essentially consists of the non-use of toxic pesticides (particularly insecticides and herbicides) and synthetic fertilizers, increases resources for both insectivorous and granivorous bird species (Caprio et al., 2015; Crowder et al., 2010; Duarte et al., 2014; Genghini et al., 2006; Kragten et al., 2011). This is a notable finding since a number of similar studies have found no significant effects of organic farming on bird communities (Assandri et al., 2016, 2017a, 2017b; Macià et al., 2012; Puig-Montserrat et al., 2017). Specifically, the studies by Assandri et al. (2016, 2017a, 2017b) were conducted in areas where vineyards only represent 2% of the total land cover and organic viticulture accounted for less than 3% of the entire vineyard surface. In our study, on the other hand, vineyards cover 15% of the land surface of the study area and organic vineyards represent 24% of all vineyards (Godia, 2015). Hence, given that pesticides drift between farms and therefore may nullify the potential benefits of organic farming (Assandri et al., 2016, 2017a,b), the differences between our findings and those of other studies could be highly relevant, suggesting that the total area and scale in which organic farming is implemented is a key factor modelling bird communities. Thus, promoting organic farming in a lower number of larger vineyard patches would offer better benefits rather than in many small fragmented vineyards (see Whittingham, 2007). As well, our results regarding the abundance of individuals of species negatively affected by climatic change are also of great interest, and are consistent with the hypothesis postulated by Jiguet et al. (2010), whereby the collapse of farmland bird communities can be explained by the combined effects of agricultural intensification and climate change (Jiguet et al., 2010). Thus, organic farming may be a useful tool for mitigating the negative effects of climate change in bird populations given that it favours those species observed to be negatively affected by global warming.

The presence of inter-row herbaceous cover between vines also had relevant effects on bird community parameters. Specifically, herbaceous cover favoured species richness in spring, particularly in organic vineyards. This would reflect the arrival of trans-Saharan migrants that in turn are mainly insectivorous and dominated the bird community (62.5%), while in winter insectivorous only represented the 36.4% of the species. In this sense, we found that the abundance of insectivorous birds was favoured by the presence of herbaceous cover in spring, especially in organic vineyards, which is consistent with Barbaro et al. (2016), who reported that total abundance of insectivorous birds was 15% higher in vineyards with full grass cover than in vineyards with partial cover alternating with bare ground. Unlike the positive effect on species richness, herbaceous cover did not have any relevant effect on overall bird abundance in conventional vineyards in winter, in a similar way to what was observed in the abundance of species negatively affected by climate change. In terms of bird abundances, the bird community in spring was mainly composed of granivorous (61.1%), which were mostly negatively affected by global warming and seemed to prefer vineyards with bare ground. Several studies had highlighted the importance of bare ground for granivorous birds (Atkinson et al., 2005; Whittingham and Markland, 2002). Thus, bare-ground vineyards would allow adequate accessibility to remaining weeds found under the vines, which provide a notable source of seeds for a great variety birds (Atkinson et al., 2005). In winter, our results are consistent with Atkinson et al. (2004), who reported a general increase in bird usage with increased amounts of bare earth in winter dry agricultural grasslands. Soil tillage carried out in winter to prevent weed growth may expose a substantial amount of seeds and invertebrates on the soil surface (Wilson et al., 1996) for a great variety of bird species, including high numbers of wintering chaffinches, which accounted for 47.2% of the overall bird abundance in winter. However, the positive relationship between overall abundance and the presence of herbaceous cover in organic vineyards in winter might be related to the non-use of toxic pesticides (particularly insecticides and herbicides) and synthetic

Table 4
Model averaged parameter estimates, standard errors and relative variable importances (RVI) of the 95% confidence set of best-ranked GLMs (with cumulative Akaike weights acc W_i, ≤0.95) explaining the effects of management, landscape and topographic variables on winter chaffinch abundance. Variables considered where ORG (organic vs. conventional farming), HCO (presence of inter-row herbaceous cover between vines vs. bare soil), VIN (% cover of vineyards), PAT (number of land cover patches), HED (length (m) of hedgerows) and ALT (altitude (m a.s.l.) of the central point of the transect). Variables in bold indicates those for which confidence intervals did not include zero.

Variable	β ± S.E.	RVI
Intercept	3.243 ± 0.698	
ORG	−0.099 ± 0.144	0.323
HCO	**−0.292 ± 0.187**	**0.426**
ORG*HCO	**0.036 ± 0.022**	**0.030**
VIN	**−1.361 ± 0.641**	**0.479**
PAT	0.004 ± 0.014	0.246
HED	$1.2 \times 10^{-4} \pm 2.0 \times 10^{-4}$	0.259
ALT	$\mathbf{-5.3 \times 10^{-4} \pm 4.7 \times 10^{-4}}$	**0.357**

fertilizers, which increases resources for both insectivorous and granivorous bird species (Caprio et al., 2015; Crowder et al., 2010; Duarte et al., 2014; Genghini et al., 2006; Kragten et al., 2011). Furthermore, despite no statistical differences being found, transects with spontaneous cover showed a higher species richness and overall abundance in both seasons. This suggested that spontaneous cover, consisting of a complex weed community, might provide more seeds and arthropods (see Bàrberi et al., 2010) than sown herbaceous covers composed of black oats (*Avena strigosa*) and a mixture of leguminous species, and so would offer greater benefits for vineyard bird communities.

Landscape heterogeneity is widely recognised as a key determinant of biodiversity in temperate agricultural systems (Benton et al., 2003). Contrary to Assandri et al. (2016, 2017b) and Pithon et al. (2016), the proportion of vineyard cover within a 200-m buffer zone around transects had positive effects on species richness in both seasons, on overall bird abundance and abundance of insectivorous species in spring. As some authors showed (Filippi-Codaccioni et al., 2010; Katayama et al., 2014; Pithon et al., 2016), habitat heterogeneity does not benefit specialist species. Therefore, differences in bird composition might explain our unexpected results. Whereas Assandri et al. (2016) and Pithon et al. (2016) calculated bird community parameters considering 59 and 45 species for spring respectively, we found 32 bird species, with a higher proportion of farmland specialists (19 bird species) accounting for 72.6% of the spring overall abundance according to Herrando et al. (2016). Yet, the negative effect of the proportion of vineyard cover on overall bird abundance in winter is quite an unexpected result, considering the arrival of birds from higher latitudes and altitudes wintering in open Mediterranean habitats (Herrando et al., 2011). Moreover, 15 bird species out of 22 could be considered farmland specialists according to Herrando et al. (2016), which accounted for 96.4% of the winter overall abundance. One possible explanation might be related to winter habitat requirements of chaffinches, whose winter abundance was strongly negatively affected by the proportion of vineyard cover within a 200-m buffer zone around transects. During this season, despite the highest abundance of this species occurring in open habitats (Herrando et al., 2011), they might prefer to forage in small vineyard patches near to woodlands and shrublands to reduce predation risk (see Whittingham and Evans, 2004). The negative effect of the number of land cover patches on species richness in both seasons and on overall bird abundance in spring, would be related to the positive effect of the proportion of vineyard cover on these parameters. Landscape heterogeneity, i.e. an increasing number of land cover patches, may increase overall species richness and abundance, but often to the detriment of open farmland habitat specialists (Pithon et al., 2016), which account for the majority of species recorded during surveys. Thus, a more heterogeneous landscape context does not necessarily influence bird communities in vineyards, at least at the scale at which this study was performed.

We also found that hedgerow length, an indirect finer-scale measure of landscape heterogeneity in farmland landscapes, had a positive effect on bird overall abundance, as observed by Assandri et al. (2016, 2017b) and Castro-Caro et al. (2015). On the contrary, hedgerows had a negative effect on the abundance of insectivorous species in winter. Indeed, our results suggest that the promotion of a hedgerow network may not be appropriate if the conservation objective is to improve habitats for declining, mostly insectivorous, open farmland specialists, as suggested by Assandri et al. (2017b) and Pithon et al. (2016). Even so, the maintenance of hedgerows does seem to be an important element in maintaining the functional biodiversity necessary for grape-pest management, as it enables an early population build-up of parasitoid wasps that prey on grape leafhoppers, the most important natural grape pest (Ponti et al., 2005). The positive effect of hedgerows on the abundance of species negatively affected by climate change might be related to certain species that require hedgerows for food supply, refuge or nesting, or to woodland species that use hedgerows as corridors connecting the woods that surround agricultural mosaics (Wegner, 1979). Examples of such birds include greenfinch, jay, woodlark, great tit, house sparrow, magpie, whinchat, blackcap, blackbird and song and mistle thrushes.

Altitude also had significant effects on vineyard bird communities, with a negative effect on species richness in winter and overall bird abundance in spring. This result is consistent with the fact that the abundances of many species in Catalonia decreases progressively with altitude (Estrada et al., 2004; Herrando et al., 2011) during the breeding season (hoopoe, crested lark, stonechat, melodious warbler, woodchat shrike, magpie, house sparrow, serin, greenfinch and goldfinch) and in winter (crested lark, meadow pipit, white wagtail, black redstart, song thrush, sardinian warbler, chiffchaff, serin, greenfinch, goldfinch and linnet). Nonetheless, we found the opposite pattern when we focussed on insectivorous birds during the breeding season. These results are consistent with the altitudinal preferences of most insectivorous birds in Catalonia (Estrada et al., 2004) during this period (woodlark, skylark, black redstart, mistle thrush, cirl bunting and corn bunting) within the altitudinal range in which the transects were located (192–845 m a.s.l.).

Finally, our results had a marked seasonal pattern. We found a greater abundance of birds and poorer species richness in winter, in agreement with Assandri et al. (2016). Thus, our results do highlight the fact that every winter Catalonia hosts about 65 million birds in wetlands and Mediterranean croplands (Herrando et al., 2011), almost twice as many as during the breeding season (Estrada et al., 2004); by contrast, the number of species present in Catalonia during the winter period is slightly lower (Estrada et al., 2004). Not surprisingly, GMLs examining the effect of factors and covariates on the overall abundance, the abundance of species negatively impacted by climatic change and the chaffinch abundance in winter (see Tables A5, A9 and A10 in Appendix A. Supplementary data) are precisely those having a higher data dispersion and a model that includes only the intercept (null model) as the best AICc model. Despite this, since the best AICc model is not strongly weighted, there is a high model selection uncertainty (Symonds and Moussalli, 2011). Therefore, model averaging still provides relevant information on the effects of selected predictors on bird community parameters.

5. Conclusions and conservation implications

Birds are commonly used as bioindicators to monitor the health of ecosystems. Over the last few decades, many populations of farmland birds have declined dramatically as a result of agricultural intensification. In addition, climate change is already having a significant impact on bird populations at European scale (Devictor et al., 2012; Gregory et al., 2009; Scheffers et al., 2016). Governments have promoted legislation aiming to conserve bird populations which focus on the maintenance of their habitats (e.g. Directives 92/43/EEC and 2009/147/EC in the European Union) and policies to promote biodiversity in agricultural landscapes, such as agri-environment schemes (AES) under the European Common Agricultural Policy. These AES are financial incentives for farmers, conditional to specific management requirements which aim to improve the ecological conditions of farms (Gamero et al., 2017). At the same time, there is growing concern about the environment and biodiversity preservation amongst general public and wine consumers, who are willing to pay a higher price for sustainable wines (Forbes et al., 2009; Sellers, 2016). Consequently, winegrowers are increasingly implementing biodiversity-friendly agricultural practices such as organic farming. In this work we provide useful information for agricultural policy makers, conservation managers and winegrowers aiming to enhance bird conservation. This study confirms the fact that organic farming has a positive effect on vineyard bird communities since, specifically, it increases species richness and overall bird abundance. This is a notable finding since other similar studies have found no significant effects. In addition, organic farming also increases the abundance of insectivorous species, which may help control vineyard pests, and promotes the conservation of bird species whose populations are declining due to climate change. Our study also demonstrates that organic farming should be implemented over a significant and compact surface area of vineyards to assure the positive effects on bird communities. Consequently, policies aimed at conserving bird communities in farmlands and, specifically, in vineyards should be implemented at broad landscape scales to ensure maximum effectiveness (see Whittingham, 2007). The presence of inter-row herbaceous cover between vines also has a positive impact on bird communities, specifically in spring and especially in organic vineyards, when herbaceous cover favours species richness and the abundance of insectivorous species. However, our results suggest that spontaneous vegetation cover might offer greater benefits for vineyard bird communities compared to sown grass cover of black oats (*Avena strigosa*) and a mixture of leguminous species. In any case, further investigation is still needed to better understand how different types of ground cover – i.e. plant origin and composition (e.g. sown vs. spontaneous vegetation) and proportion of vegetation cover (full vs. partial vegetation cover) – perform as tools for wildlife conservation.

Jiguet et al. (2010) have suggested that the way species respond to climate change is likely to vary in terms of habitat type and composition. Thus, an understanding of these interactions will be necessary if habitats are to be managed appropriately through adaptation strategies to reduce the negative impact of climate change on biodiversity. To the best of our knowledge, this is the first time that the effects of (a) organic as opposed to conventional farming and the (b) presence of inter-row herbaceous cover within vineyards as opposed to bare soil have been tested on vineyard bird communities as part of an attempt to safeguard species negatively affected by global warming. This approach also opens a line for future research into agricultural practices under a scenario of climate change, which should consider not only the effects on wildlife but also on the emission of carbon dioxide (CO_2) and other greenhouse gases into the atmosphere.

Acknowledgements

We are grateful to the wine brand ‘Bodegas Torres’ for allowing us to work in their vineyards and for funding the research carried out by the Conservation Biology Group of the University of Barcelona. We are particularly grateful to Miquel Agustí Torres for his interest on our research and conservation projects. We would also like to thank all people from ‘Bodegas Torres’ that helped us during this project. Thanks are due also to Joan Font, Antoni Pajares, Xavier Sort, Josep Amadó, Rosa Maria Domènech and Eduald Crivillé. We greatly appreciate comments from two anonymous reviewers on a previous version of the manuscript.

Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.agee.2018.09.029.

References

Arlettaz, R., Maurer, M.L., Mosimann-Kampe, P., Nusslé, S., Abadi, F., Braunisch, V., Schaub, M., 2012. New vineyard cultivation practices create patchy ground vegetation favouring Woodlarks. J. Ornithol. 253, 229–238. https://doi.org/10.1007/s10336-011-0737-7.

Assandri, G., Bogliani, G., Pedrini, P., Brambilla, M., 2016. Diversity in the monotony? Habitat traits and management practices shape avian communities in intensive vineyards. Agric. Ecosyst. Environ. 223, 250–260. https://doi.org/10.1016/j.agee.2016.03.014.

Assandri, G., Giacomazzo, M., Brambilla, M., Griggio, M., Pedrini, P., 2017a. Nest density, nest-site selection, and breeding success of birds in vineyards: management implications for conservation in a highly intensive farming system. Biol. Conserv. 205, 23–33. https://doi.org/10.1016/j.biocon.2016.11.020.

Assandri, G., Bogliani, G., Pedrini, P., Brambilla, M., 2017b. Assessing common birds’ ecological requirements to address nature conservation in permanent crops: lessons from Italian vineyards. J. Environ. Manage. 191, 145–154. https://doi.org/10.1016/j.jenvman.2016.12.071.

Atkinson, P.W., Buckingham, D., Morris, A.J., 2004. What factors determine where invertebrate-feeding birds forage in dry agricultural grasslands? Ibis 146, 99–107. https://doi.org/10.1111/j.1474-919X.2004.00346.x.

Atkinson, P.W., Fuller, R.J., Vickery, J.A., Conway, G.J., Tallowin, J.R.B., Smith, R.E.N., Haysom, K.A., Ings, T.C., Asteraki, E.J., Brown, V.K., 2005. Influence of agricultural management, sward structure and food resources on grassland field use by birds in lowland England. J. Appl. Ecol. 42, 932–942. https://doi.org/10.1111/j.1365-2664.2005.01070.x.

Barbaro, L., Rusch, A., Muiruri, E.W., Gravellier, B., Thiery, D., Castagneyrol, B., 2016. Avian pest control in vineyards is driven by interactions between bird functional diversity and landscape heterogeneity. J. Appl. Ecol. 54, 500–508. https://doi.org/10.1111/1365-2664.12740.

Bàrberi, P., Burgio, G., Dinelli, G., Moonen, A.C., Otto, S., Vazzana, C., Zanin, G., 2010. Functional biodiversity in the agricultural landscape: relationships between weeds and arthropod fauna. Weed Res. 50, 388–401. https://doi.org/10.1111/j.1365-3180.2010.00798.x.

Bengtsson, J., Ahnström, J., Weibull, A.C., 2005. The effects of organic agriculture on biodiversity and abundance: a meta-analysis. J. Appl. Ecol. 42, 261–269. https://doi.org/10.1111/j.1365-2664.2005.01005.x.

Benton, T.M., Vickery, J.A., Wilson, J.D., 2003. Farmland biodiversity: is habitat heterogeneity the key? Trends Ecol. Evol. 18 (4), 182–188. https://doi.org/10.1016/S0169-5347(03)00011-9.

Burnham, K.P., Anderson, D.R., 2002. Model Selection and Inference: a Practical Information-theoretic Approach, 2nd ed. Springer-Verlag, New York.

Caprio, E., Nervo, B., Isaia, M., Allegro, G., Rolando, A., 2015. Organic versus conventional systems in viticulture: comparative effect on spiders and carabids in vineyards and adjacent forests. Agric. Ecosyst. Environ. 136, 61–69. https://doi.org/10.1016/j.agsy.2015.02.009.

Castro-Caro, J.C., Barrio, I.C., Tortosa, F.S., 2015. Effects of Hedges and herbaceous cover on passerine communities in Mediterranean olive groves. Acta Ornithol. 50 (2), 180–192. https://doi.org/10.3161/00016454AO2015.50.2.006.

Concepción, E.D., Díaz, M., Baquero, R.A., 2008. Effects of landscape complexity on the ecological effectiveness of agrienvironmental schemes. Landsc. Ecol. 23, 135–148. https://doi.org/10.1007/s10980-007-9150-2.

Crowder, D.W., Northfield, T.D., Strand, M., Snyder, W.E., 2010. Organic agriculture promotes evenness and natural pest control. Nature 46, 109–112. https://doi.org/10.1038/nature09183.

Del Hoyo, J., Elliott, A., Sargatal, J., Christie, D.A., de Juana, E. (Eds.), 2017. Handbook of the Birds of the World Alive. Lynx Edicions, Barcelona retrieved from. http://www.hbw.com/ on 29.09.2017.

Devictor, V., van Swaay, C., Brereton, T., Brotons, L., Chamberlain, D., Heliölä, J., Herrando, S., Julliard, R., Kuussaari, M., Lindström, Å., Reif, J., Roy, D.B., Schweiger, O., Settele, J., Stefanescu, C., Van Serien, A., Van Turnhout, C., Vermouzek, Z., DeVries, M.W., Wynhoff, I., Jiguet, F., 2012. Differences in the climatic debts of birds and butterflies at a continental scale. Nat. Clim. Change 2, 121–124. https://doi.org/10.1038/nclimate1347.

Donald, P.F., Green, R.E., Heath, M.F., 2001. Agricultural intensification and the collapse of Europe’s farmland bird populations. Proc. R. Soc. Lond. B 268, 25–29. https://doi.org/10.1098/rspb.2000.1325.

Dormann, C.F., Elith, J., Bacher, S., Buchmann, C., Carl, G., Carré, G., Marquéz, J.R.G., Gruber, B., Lafourcade, B., Leitão, P.J., Münkemüller, T., McClean, C., Osborne, P.E., Reineking, B., Schröder, B., Skidmore, A.K., Zurell, D., Lautenbach, S., 2013. Collinearity: a review of methods to deal with it and a simulation study evaluating their performance. Ecography 36, 27–46. https://doi.org/10.1111/j.1600-0587.2012.07348.x.

Duarte, J., Farfán, M.A., Fa, J.E., Vargas, J.M., 2014. Soil conservation techniques in vineyards increase passerine diversity and crop use by insectivorous birds. Bird Study 61 (2), 193–203. https://doi.org/10.1080/00063657.2014.901294.

Estrada, J., Pedrocchi, V., Brotons, L., Herrando, S. (Eds.), 2004. Atles dels ocells nidificants de Catalunya 1999–2002. Institut Català d’Ornitologia (ICO)/Lynx Edicions, Barcelona.

Filippi-Codaccioni, O., Devictor, V., Bas, Y., Julliard, R., 2010. Toward more concern for specialisation and less forspecies diversity in conserving farmland biodiversity. Biol. Conserv. 143 (6), 1493–1500. https://doi.org/10.1016/j.biocon.2010.03.031.

Firbank, L.G., Petit, S., Smart, S., Blain, A., Fuller, R.J., 2008. Assessing the impacts of agricultural intensification on biodiversity: a British perspective. Philos. Trans. Biol. Sci. 363, 777–787. https://doi.org/10.1098/rstb.2007.2183.

Forbes, S.L., Cohen, D.A., Cullen, R., Wratten, S.D., Fountain, J., 2009. Consumer attitudes regarding environmentally sustainable wine: an exploratory study of the New Zealand marketplace. J. Clean. Prod. 17 (13), 1195–1199. https://doi.org/10.1016/j.jclepro.2009.04.008.

Fowler, J., Cohen, L., 1992. Practical Statistic for Field Biology. Wiley & Sons, New York.

Fuller, R.J., Norton, L.R., Feber, R., Johnson, P.J., Chamberlain, D.E., Joys, A.C., Mathews, F., Stuart, R.C., Townsend, M.C., Manley, W.J., Wolfe, M.S., Macdonald, D.W., Firbank, L.G., 2005. Benefits of organic farming to biodiversity vary among taxa. Biol. Lett. 1, 431–434. https://doi.org/10.1098/rsbl.2005.0357.

Gamero, A., Brotons, L., Brunner, A., Foppen, R., Fornasari, L., Gregory, R.D., Herrando, S., Hořák, D., Jiguet, F., Kmecl, P., Lehikoinen, A., Lindström, Å., Paquet, J.-Y., Reif, J., Sirkiä, P.M., Škorpilová, J., van Strien, A., Szép, T., Telenský, T., Teufelbauer, N., Trautmann, S., van Turnhout, C.A.M., Vermouzek, Z., Vikstrøm, T., Voříšek, P., 2017. Tracking progress toward EU biodiversity strategy targets: EU policy effects in preserving its common farmland birds. Conserv. Lett. 10, 395–402. https://doi.org/10.1111/conl.12292.

Genghini, M., Gellini, S., Gustin, M., 2006. Organic and integrated agriculture: the effects on bird communities in orchard farms in northern Italy. Biodivers. Conserv. 15, 3077–3094. https://doi.org/10.1007/s10531-005-5400-2.

Godia, J., 2015. La viticultura ecològica a Catalunya. Vilafranca del Penedès, 25 de novembre de 2015. 3r Simposi de Producció Agrària Ecològica, Viticultura i Enologia ecològica. Departament d'Agricultura, Ramaderia, Pesca i Alimentació. Generalitat de Catalunya. http://incavi.gencat.cat/web/.content/00-actualitat/3r-simposi-2015/fitxers-binaris/Presentacio-Joan-Godia-Tresanchez.pdf.

Greene, W., 2002. Econometric Analysis. Prentice Hall International edition.

Gregory, R.D., van Strien, A., Vorisek, P., Gmelig Meyling, A.W., Noble, D.G., Foppen, R.P.B., Gibbons, D.W., 2005. Developing indicators for European birds. Philos. Trans. Biol. Sci. 360, 269–288. https://doi.org/10.1098/rstb.2004.1602.

Gregory, R.D., Willis, S.G., Jiguet, F., Voříšek, P., Klvaňová, A., van Strien, A., Huntley, B., Collingham, Y.C., Couvet, D., Green, R.E., 2009. An indicator of the impact of climatic change on European bird populations. PLoS One 4 (3), e4678. https://doi.org/10.1371/journal.pone.0004678.

Guerrero, I., Morales, M.B., Oñate, J.J., Geiger, F., Berendse, F., de Snoo, G., Eggers, S., Pärt, T., Bengtsson, J., Clement, L.W., Weisser, W.W., Olszewski, A., Ceryngier, P., Hawro, V., Liira, J., Aavik, T., Fischer, C., Flohre, A., Thies, C., Tscharntke, T., 2012. Response of ground-nesting farmland birds to agricultural intensification across Europe: landscape and field level management factors. Biol. Conserv. 152, 74–80. https://doi.org/10.1016/j.biocon.2012.04.001.

Guyot, C., Arlettaz, R., Korner, P., Jacot, A., 2017. Temporal and spatial scales matter: circannual habitat selection by bird communities in vineyards. PLoS One 12 (2), e0170176. https://doi.org/10.1371/journal.pone.0170176.

Heck, R.H., Thomas, S.L., Tabata, L.N., 2012. Multilevel Modeling of Categorical Outcomes Using IBM SPSS. Taylor and Francis Group, New York.

Henle, K., Alard, D., Clitherow, J., Cobb, P., Firbank, L., Kull, T., McCracken, D., Moritz, R.F.A., Niemelä, J., Rebane, M., Wascher, D., Watt, A., Young, J., 2008. Identifying and managing the conflicts between agriculture and biodiversity conservation in Europe–a review. Agric. Ecosyst. Environ. 124, 60–71. https://doi.org/10.1016/j.agee.2007.09.005.

Herrando, S., Brotons, L., Estrada, J., Guallar, S., Anton, M. (Eds.), 2011. Atles dels ocells de Catalunya a l'hivern 2006-2009. Institut Català d'Ornitologia (ICO)/Lynx Edicions, Barcelona.

Herrando, S., Brotons, L., Anton, M., Páramo, F., Villero, D., Titeux, N., Quesada, J., Stefanescu, C., 2015. Assessing impacts of land abandonment on Mediterranean biodiversity using indicators based on bird and butterfly monitoring data. Environ. Conserv. 43 (1), 69–78. https://doi.org/10.1017/S0376892915000260.

Herrando, S., Anton, M., Garcia, D., Brotons, L., 2016. Common bird monitoring scheme in winter in Catalonia (NE Spain): opportunities and constraints to enlarge our view for farmland bird indicators. Bird Census News 29 (1–2), 23–24.

Jarzyna, M.A., Zuckerberg, B., Finley, A.O., Porter, W.F., 2016. Synergistic effects of climate and land cover: grassland birds are more vulnerable to climate change. Landsc. Ecol. 31, 2275–2290. https://doi.org/10.1007/s10980-016-0399-1.

Jiguet, F., Gregory, R.D., Devictor, V., Green, R.E., Voříšek, P., Van Strien, A., Couvet, D., 2010. Population trends of European common birds are predicted by characteristics of their climatic niche. Glob. Change Biol. Bioenergy 16, 497–505. https://doi.org/10.1111/j.1365-2486.2009.01963.x.

Katayama, N., Amano, T., Naoe, S., Yamakita, T., Komatsu, I., Takagawa, S., Sato, N., Ueta, M., Miyashita, T., 2014. Landscape heterogeneity–biodiversity relationship: effect of range size. PLoS One 9 (3), e93359. https://doi.org/10.1371/journal.pone.0093359.

Kragten, S., Tamis, W., Gertenaar, E., Midcap Ramiro, S., Van Der Poll, R., Wang, J., De Snoo, G., 2011. Abundance of invertebrate prey for birds on organic and conventional arable farms in the Netherlands. Bird Conserv. Int. 21 (1), 1–11. https://doi.org/10.1017/S0959270910000079.

Macià, F.X., Torre, I., Torrentó, J.R., 2012. Protocol for assessing bird abundance and richness in vineyards. A case study in Penedès area. BioDiVine Lleida Congress.

Norris, K., 2008. Agriculture and biodiversity conservation: opportunity knocks. Conserv. Lett. 1 (1), 2–11. https://doi.org/10.1111/j.1755-263X.2008.00007.x.

Oliver, T.H., Morecroft, M.D., 2014. Interactions between climate change and land use change on biodiversity: attribution problems, risks, and opportunities. WIREs Clim. Change 5, 317–335. https://doi.org/10.1002/wcc.271.

Pfiffner, L., Balmer, O., 2011. Factsheet Organic Agriculture and Biodiversity. Research Institute of Organic Agriculture (FiBL).

Pithon, J.A., Beaujouan, V., Daniel, H., Pain, G., Vallet, J., 2016. Are vineyards important habitats for birds at local or landscape scales? Basic Appl. Ecol. 17, 240–251. https://doi.org/10.1016/j.baae.2015.12.004.

Ponti, L., Ricci, C., Veronesi, F., Torricelli, R., 2005. Natural hedges as an element of functional biodiversity in agroecosystem: the case of a central Italy vineyard. Bull. Insectol. 58, 19–23.

Puig-Montserrat, X., Stefanescu, C., Torre, I., Palet, J., Fàbregas, E., Dantart, J., Arrizabalaga, A., Flaquer, C., 2017. Effects of organic and conventional crop management on vineyard biodiversity. Agric. Ecosyst. Environ. 243, 19–26. https://doi.org/10.1016/j.agee.2017.04.005.

QGIS Development Team, 2014. QGIS Geographic Information System. Open Source Geospatial Foundation Project. http://www.qgis.org/.

Quinn, G., Keough, M., 2002. Experimental Design and Data Analysis for Biologists. Cambridge University Press, Cambridge.

Ramos, M.C., Jones, G.V., Martínez-Casasnovas, J.A., 2008. Structure and trends in climate parameters affecting winegrape production in northeast Spain. Clim. Chang. Res. Lett. 38, 1–15. https://doi.org/10.3354/cr00759.

Rosenberg, M.S., Anderson, C.D., 2011. PASSaGE: pattern analysis, spatial statistics and geographic exegesis. Version 2. Methods Ecol. Evol. 2 (3), 229–232. https://doi.org/10.1111/j.2041-210X.2010.00081.x.

Scheffers, B.R., De Meester, L., Bridge, T.C.L., Hoffmann, A.A., Pandolfi, J.M., Corlett, R.T., Butchart, S.H.M., Pearce-Kelly, P., Kovacs, K.M., Dudgeon, D., Pacifici, M., Rondinini, C., Foden, W.B., Martin, T.G., Mora, C., Bickford, D., Watson, J.E.M., 2016. The broad footprint of climate change from genes to biomes to people. Science 354 (6313). https://doi.org/10.1126/science.aaf7671.

Sellers, R., 2016. Would you pay a price premium for a sustainable wine? The voice of the Spanish consumer. Agric. Agric. Sci. Procedia 8, 10–16. https://doi.org/10.1016/j.aaspro.2016.02.003.

Symonds, M., Moussalli, A., 2011. A brief guide to model selection, multimodel inference and model averaging in behavioural ecology using Akaike's information criterion. Behav. Ecol. Sociobiol. 65, 13–21. https://doi.org/10.1007/s00265-010-1037-6.

Verhulst, J., Báldi, A., Kleijn, D., 2004. Relationship between land-use intensity and species richness and abundance of birds in Hungry. Agric. Ecosyst. Environ. 104, 465–473. https://doi.org/10.1016/j.agee.2004.01.043.

Wegner, J.F., Merriam, G., 1979. Movements by birds and small mammals between a wood and adjoining farmland habitats. J. Appl. Ecol. 16, 349–357. http://www.jstor.org/stable/2402513.

Whittingham, M.J., 2007. Will agri-environment schemes deliver substantial biodiversity gain, and if not why not? J. Appl. Ecol. 44, 1–5. https://doi.org/10.1111/j.1365-2664.2006.01263.x.

Whittingham, M.J., Evans, K.L., 2004. The effects of habitat structure on predation risk of birds in agricultural landscapes. Ibis 146, 210–220. https://doi.org/10.1111/j.1474-919X.2004.00370.x.

Whittingham, M.J., Markland, H.M., 2002. The influence of substrate on the functional response of an avian granivore and its implications for farmland bird conservation. Oecologia 130, 637–644. https://doi.org/10.1007/s00442-001-0850-z.

Willer, H., Lernoud, J., 2016. The world of organic agriculture. Statistics and emerging trends 2016. FiBL-IFOAM report. Research Institute of Organic Agriculture (FiBL), Frick, and IFOAM – Organics International, Bonn.

Wilson, J.D., Taylor, R., Muirhead, L.B., 1996. Field use by farmland birds in winter: an analysis of field type preferences using resampling methods. Bird Study 43 (3), 320–332. https://doi.org/10.1080/00063659609461025.

Zuur, A.F., Ieno, E.N., Elphick, C.S., 2010. A protocol for data exploration to avoid common statistical problems. Methods Ecol. Evol. 1, 3–14. https://doi.org/10.1111/j.2041-210X.2009.00001.x.

Zuur, A.F., Hilbe, J.M., Ieno, E.N., 2013. A Beginner's Guide to GLM and GLMM with R: a Frequentist and Bayesian Perspective for Ecologists. Highland Statistic.