Avian community responses to the establishment of small garden allotments within a Mediterranean habitat mosaic

J. Quesada & I. MacGregor–Fors

Quesada, J. & MacGregor–Fors, I., 2010. Avian community responses to the establisment of small garden allotments within a Mediterranean habitat mosaic. *Animal Biodiversity and Conservation*, 33.1: 53–61.

Abstract

Avian community responses to the establishment of small garden allotments within a Mediterranean habitat mosaic.— Ecological studies focused on small–scale habitat alterations have found positive, null, and negative effects on biodiversity. In this study, we describe the effects that establishing a relatively small area of garden allotments had on bird communities. To assess such effects, we analyzed avian community diversity (*i.e.*, species richness and abundance) and behavioral traits (*i.e.*, foraging, perching). Although land transformation was recent and on a small geographic–scale, our results showed that bird communities in the allotments were dominated by a few species, while in the almond plantation (former habitat) evenness was higher. When perching and foraging behavior was compared in the two study areas, we found a significantly higher proportion of foraging in the garden allotments, and a higher proportion of birds perching in the naturalized plantation. Although new habitats often enhance regional bird species richness in Mediterranean landscapes, we found no evidence of an increase in regional avian diversity related to the establishment of small garden allotments. We propose that future harvesting activities should consider the scale, intensity, and frequency of the generated perturbation in order to promote biodiversity.

Key words: Avian ecology, Biodiversity, Bird communities, Land–use transformation.

Resumen

Respuestas de una comunidad de aves al establecimiento de un pequeño huerto dentro de un hábitat Mediterráneo en mosaico.— Estudios previos de ecología enfocados a los efectos que tienen las alteraciones de los hábitats a pequeña escala han hallado efectos positivos, nulos y negativos sobre la biodiversidad. En este trabajo describimos los efectos que tiene el establecimiento de un pequeño huerto sobre la comunidad de aves. Para ello, analizamos los valores de diversidad (*i.e.*, riqueza de especies y abundancia) y el comportamiento (*i.e.*, forrajeo, uso de perchas) de las comunidades de aves. Los resultados de este trabajo muestran que, aunque el cambio de uso de suelo es reciente y a pequeña escala, las comunidades de aves observadas en el huerto están dominadas por unas pocas especies, mientras que mostraron ser mayormente equitativas en las plantaciones naturalizadas de almendros (hábitat previo al establecimiento de los huertos). Cuando comparamos el comportamiento de las aves en ambos hábitats, encontramos una mayor proporción de aves en búsqueda activa de alimento en los huertos, mientras que el número de aves desarrollando otras actividades (descanso) fue mayor en las plantaciones naturalizadas. Aunque la presencia de nuevos hábitats puede elevar la riqueza regional de la avifauna en paisajes mediterráneos, nuestros resultados no muestran evidencia de un efecto positivo significativo en el aumento de la riqueza regional de aves debido al establecimiento de pequeños huertos. Proponemos que las futuras actividades agrícolas deban tener en cuenta la escala, intensidad y frecuencia de las perturbaciones generadas con la finalidad de lograr un efecto positivo sobre la biodiversidad.

Palabras clave: Ecología aviar, Biodiversidad, Comunidades de aves, Transformación del uso del suelo.

(Received: 21 IX 09; Conditional acceptance: 7 XII 09; Final acceptance: 26 III 10)

ISSN: 1578–665X

J. Quesada, Institut Català d'Ornitologia, Barcelona, España (Spain).– I. MacGregor–Fors, Lab. de Ecología Funcional, Centro de Investigaciones en Ecosistemas, Univ. Nacional Autónoma de México, Campus Morelia, Antigua Carretera a Pátzcuaro 8701, Morelia 58190, Michoacán, México.

Corresponding author: J. Quesada. E–mail: analisi@ornitologia.org

Introduction

Agricultural activities generate increasing land–use change worldwide (Vitousek et al., 1997; Schroter et al., 2005). This phenomenon is closely related to changes in the nature and dynamics of biotic communities, leading to community ecology shifts such as the invasion and domination of wildlife communities by a few generalist and/or opportunistic species, and even to the extinction of those species sensitive to habitat alterations (Vitousek et al., 1997; Czech et al., 2000). Previous studies have shown that habitat change can affect biodiversity positively or negatively (Burel et al., 1998; Benton et al., 2003; Sax & Gaines, 2003; Lepczyk et al., 2008), largely depending on the environmental heterogeneity generated by the anthropogenic modification of habitats (Mason & MacDonald, 2000; Benton et al., 2003; Herrando et al., 2003; Pons et al., 2003; Suárez–Seoane et al., 2002). However, differences in the effects that land–use change have on biodiversity are difficult to predict due to the magnitude of change and the differential response of species, with some of them being positively affected and others negatively affected by such modifications (Blair, 1996; Devictor et al., 2008).

Knowing the ecological effect of small–scale environmental alterations can aid local landscape management activities and wildlife conservation strategies (Pickett & Cadenassso, 1995; Gutzwiller, 2002). In this study we describe the response of bird communities to the establishment of a series of small garden allotments in an area that was modified ~50 years ago from Mediterranean vegetation to almond plantations. These areas are now abandoned and are conceived as naturalized, creating a typical Mediterranean mosaic grid that includes both natural and/or naturalized vegetation, and crops. To assess the effect of such land–use transformation on bird communities, we compared bird species richness, abundance, and evenness in abandoned naturalized almond plantations (including scattered Mediterranean vegetation patches) with an area of recently established small garden allotments. We also assessed the species turnover rate between these two habitats, and evaluated how birds used them. To do so, we recorded perching and feeding activities. We used birds as ecological models to evaluate the effect of habitat replacement because they are highly conspicuous, relatively easy to survey, and sensitive to habitat changes. Furthermore, they constitute complex communities in almost every natural and human–altered ecosystem (Furness & Greenwood, 1993; Gregory et al., 2009; MacGregor–Fors et al., 2009). We expected bird species richness to be higher in naturalized almond plantations due to their closed canopy, but predicted that bird abundances would be higher in the garden allotments due to the quantity and availability of a variety of human–produced food resources. We also predicted differences in the way in which birds use each of the studied habitats.

Methods

Study area

This study was conducted in Abrera (Catalunya), north east Spain (41° 31' 07'' N, 1° 53' 55'' E; ~65 m a.s.l.). Main plant assemblages in this area include abandoned almond tree (*Prunus* spp.) plantations (50 years old) with scattered patches of Mediterranean vegetation (referred to as almond plantations hereafter). Thus, although the origin of this habitat is anthropogenic, it has become a naturalized habitat due to abandonment and its vegetation structure including open patches covered with an understory of herbaceous plants and native bushes (*e.g.*, *Quercus coccifera, Pistacia lentiscus, Erica arborea*) with scattered Mediterranean trees dominated by Holm Oaks (*Quercus ilex*) and Aleppo Pine trees (*Pinus halepensis)*. In 2002, an approximate area of 2.4 hectares of the naturalized almond plantation was transformed into 20 x 20 m garden allotments for recreational and non–commercial purposes. These allotments are basically comprised of herbaceous crops, such as corn, potatoes and legumes, and a few scattered almond trees.

Bird surveys

To evaluate avian responses to the establishment of the garden allotments, we compared bird communities therein with those in the adjacent former almond plantation. Birds were surveyed during winter, the breeding season, and post–breeding migration of 2005. We carried out bird surveys on seven separate days throughout the year in each habitat, starting one hour after dawn. We used the area search method (Ralph et al., 1993) recording all birds present in the surveyed areas for 30 minutes. Because the allotment area was relatively small, the size of the naturalized almond plantation we studied was also small. Although the two habitats were contiguous, we selected survey sites that were located 300 m apart to assure survey independence (Bibby et al., 1992; Ralph et al., 1993).

Statistical analyses

To assure a representative sample of bird communities within the garden allotments and almond plantations, we calculated the mean predicted species richness for both habitats using ACE, an abundance–based coverage estimator (SPADE; Chao & Shen, 2006). ACE uses the coefficient of variance of a sub–sample of rare species, determined by a cut–off point, to characterize the degree of heterogeneity for the probability of species detection, to estimate the number of missing species in a given sample, and to calculate a statistical expectation of the predicted species based on a given sample (Chao & Lee, 1992).

Species rank/abundance plots were used to compare bird community evenness among both studied habitats (as recommended by Magurran, 2004). Rank/abundance plots are often used to represent distribution of species abundance in a community. They highlight differences in dominance/evenness among communities; steep curves represent assemblages with high dominance of a few species, and shallower slopes imply communities with higher evenness where species share similar abundances. The steepness of the slope of rank/abundance plots allows to infer the processes determining the diversity of a community, and reflects the success of the implied species to compete for limited resources (Magurran, 2004). Because ranked abundances did not follow a normal distribution, data were transformed (log_{10}). To test differences in the slopes of both rank/abundance regression lines, we performed Ancova. Bird abundances recorded in both surveyed habitats were also compared using a generalized linear model (one way GLZ Anova Model) considering a Poisson distribution. We contrasted the richness values of bird species recorded in the garden allotments and adjacent almond plantations using rarefaction curves (Sobs Mao Tao ± 95% confidence intervals; EstimateS platform; Colwell, 2005). Rarefaction curves are based on the repeated re–sampling of all pooled samples, representing the statistical expectation of species richness in sample (Gotelli & Colwell, 2001; Colwell, 2005). To determine if species richness values were statistically different between the studied habitats, we compared their 95% confidence intervals. When confidence intervals did not overlap, $\alpha < 0.01$ was considered statistically significant (following Payton et al., 2003; M. Payton, pers. com.).

We assessed the species turnover rate between the two studied habitats using a recently proposed index ($ß_{sim}$; Lennon et al., 2001). $ß_{sim}$ quantifies the relative magnitude of species gains and losses in relation to the sample with less unique species, allowing the identification of species loss or shift in relation to the sample with more unique species (Koleff et al., 2003; Gaston et al., 2007). Also, we analyzed differences in the proportion of species pertaining to recorded trophic guilds in both studied habitats using a contingency table chi–square test.

To evaluate differences in the way that birds used both study habitats, we recorded the activity carried out by every sight–recorded bird. Two activities were recorded in sample sizes sufficient to conduct robust statistical analyses: (1) foraging; and (2) perching. Behavioral observations were recorded simultaneously with the area search surveys. To compare differences in the number of birds feeding and perching within the studied habitats, we performed a general linearized model (GLZ: two–way Anova Model), following a Poisson distribution, where bird abundance was the dependent variable, and the predictors were habitat and behavior (perching and foraging).

Results

Analysis of species prediction revealed that our survey method was sufficient to record a representative sample of the bird communities present in both habitats during the study period. The number of bird species recorded in naturalized almond plantations and garden allotments comprised 86.3 and 85.4% of their mean bird richness prediction respectively (ACE = 33.6 and 23.4 species, respectively).

We recorded a total of 34 bird species of 24 genera, six of which are considered regionally endangered (*sensu* Estrada et al., 2004). Of the total 34 species, 29 were recorded in naturalized almond plantations, pertaining to five main feeding groups: insectivores (31%), omnivores (31%), granivores (21%), frugivores (10%), and carnivores (7%). In contrast, we only recorded 20 species in the garden allotments, of which 30% were granivores, 30% omnivores, 25% insectivores, 10% frugivores, and 5% carnivores (table 1).

Bird communities recorded in the allotment area were highly dominated by a small number of species, while communities in the almond plantations were fairly even (ANCOVA $F_{1,45} = 13.36$, $p < 0.001$; fig. 1). Bird abundances differed between the studied habitats, with higher values in the garden allotments (Wald = 4.15, df = 1, $p < 0.05$; table 2). We also found differences in the richness of bird species between the two habitats. When we compared the computed rarefaction curves from both communities, using an abundance cut–off point of 143 individuals (total abundance value for almond plantations, the least abundant community), almond plantations showed a significantly higher species richness (27.0 ± 5.7) than those in the garden allotments (14.8 ± 4.9; fig. 2).

Of the total recorded bird species, 15 were shared by both habitats, 14 were unique to almond plantations, and 5 were unique to the allotments, although two of the latter were probably accidental (*i.e.*, *Lanius meridionalis, Sylvia melanocephala*) as they typically belong to Mediterranean mosaic habitats. Thus, the species turnover analysis was low ($ß_{sim} = 0.25$). However, we did not find differences in the proportion of species pertaining to the recorded trophic guilds in the two habitats ($\chi^2 = 4.99$, df = 4, $p = 0.28$).

Based on our bird behavioral measures (*i.e.*, number of perching and foraging birds), avian activity differed between the two study habitats. We recorded a significantly higher number of birds perching in naturalized almond plantations, while a significantly higher number of foraging birds was found in the garden allotments (GLZ: habitat: Wald = 4.45, $p < 0.05$; activity: Wald = 5.25, $p < 0.05$: activity x habitat: Wald = 26.22, $p < 0.001$; fig. 3).

Discussion

Results from this study showed that the bird communities in the recently established garden allotments differed from those recorded in adjacent naturalized almond plantations. Bird communities in the newly created garden allotments had lower bird species richness but higher bird density, mainly comprised of three species (58% of the total recorded abundance): Eurasian Tree Sparrow (*Passer montanus*), Barn Swallow (*Hirundo rustica*), and European Serin (*Serinus serinus*). High abundance of these species was not surprising as they are typically associated

Table 1. Bird species recorded in the surveyed garden allotment area and naturalized almond plantations (Mediterranean mosaic). Total number of individuals recorded for each species is reported: Trophic guild (Tg): C. Carnivore; F. Frugivore; G. Granivore; I. Insectivore; O. Omnivore. Conservation status (Cs, *sensu* Estrada et al., 2004): LC. Least concern; NT. N. Near threatened; VU. Vulnerable; CR. Critical. Habitat: Ap. Naturalized almond plantations. Ga. Garden allotments.

Tabla 1. Especies de aves observadas en la zona de huertos y en plantaciones de almendros naturalizadas (mosaico mediterráneo). Se incluye el número total de individuos observados de cada especie registrados: Grupo trófico (Tg): C. Carnívoro; F. Frugívoro; G. Granívoro; I. Insectívoro; O. Omnívoro. Estado de conservación (Cs, sensu *Estrada et al., 2004): LC. Preocupación menor; NT. Casi amenazada; VU. Vulnerable; CR. Critico. Hábitat: Ap. Plantaciones de almendros naturalizadas. Ga. Área de huertos.*

				Habitat	
Family	Species	Tg	Cs	Ap	Ga
Ardeidae	*Ardea cinerea*	C	NT	1	
Columbidae	*Columba palumbus*	G	LC	2	2
Meropidae	*Merops apiaster*	I	LC	4	1
Upupidae	*Upupa epops*	I	LC	3	
Picidae	*Picus viridis*	I	LC	1	
Hirundinidae	*Hirundo rustica*	I	LC		44
Turdidae	*Erithacus rubecula*	O	LC	2	2
	Phoenicurus ochruros	I	LC	6	
	Phoenicurus phoenicurus	I	CR	2	2
	Turdus merula	F	LC	1	1
	Turdus philomelos	F	LC	2	18
	Turdus viscivorus	F	LC	1	
Syliviidae	*Sylvia melanocephala*	I	LC		2
	Sylvia atricapilla	I	LC	6	2
	Phylloscopus collybita	I	LC	2	
	Regulus ignicapilla	O	LC	5	
Muscicapidae	*Muscicapa striata*	I	NT	1	
Aeigthalidae	*Aegithalos caudatus*	O	LC	14	
Paridae	*Parus caeruleus*	O	LC	1	
	Parus major	O	LC	9	3
Certhiidae	*Certhia brachydactyla*	I	LC	2	
Laniidae	*Lanius meridionalis*	C	VU		1
Corvidae	*Pica pica*	O	LC	10	13
Sturnidae	*Sturnus vulgaris*	O	LC	23	1
	Sturnus unicolor	O	LC	2	
Passeridae	*Passer domesticus*	O	LC	11	16
	Passer montanus	O	NT	19	45
Fringilidae	*Coccothraustes coccothraustes*	G	NT	10	
	Fringilla coelebs	G	LC		1
	Serinus serinus	G	LC	7	35
	Carduelis chloris	G	LC	4	4
	Carduelis carduelis	G	LC	13	17
	Carduelis spinus	G	NT	8	
	Carduelis cannabina	G	LC		2

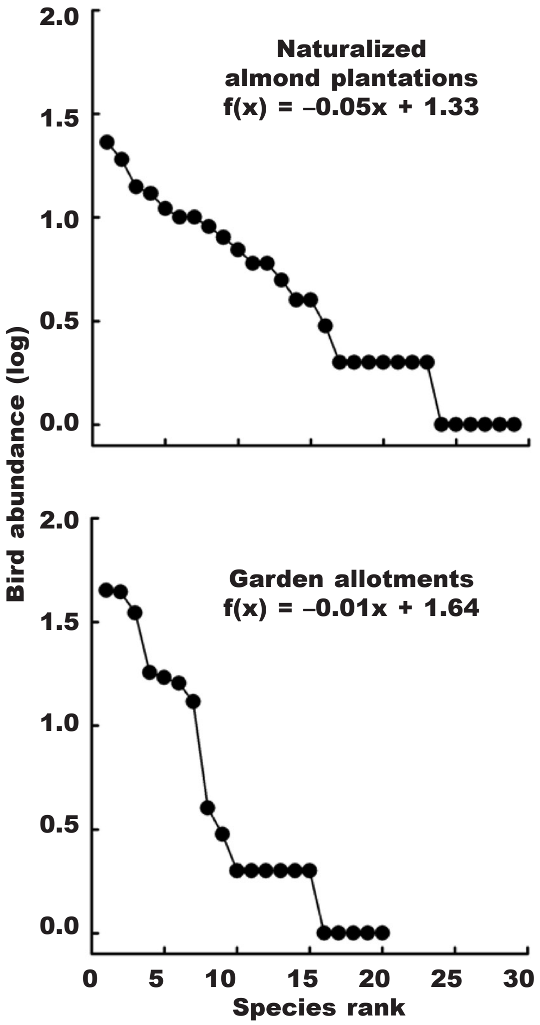

Fig. 1. Rank/abundance plots for the recorded bird communities in the studied naturalized almond plantations and garden allotments. The equation of the regression line for each rank/abundance plot is displayed.

Fig. 1. Gráficas de rango/abundancia de las comunidades de aves de las zonas estudiadas de plantaciones de almendros naturalizadas y áreas de huertos. Se muestra la ecuación de la línea de regresión para cada curva de rango/abundancia.

Table 2. Bird species richness and abundance recorded in the studied naturalized almond plantations and garden allotments. Abundance values represent averages (± SD) from the seven surveys: Ap. Naturalized almond plantations; Ga. Garden allotments.

Tabla 2. Riqueza de especies de aves y abundancia, registradas en las áreas estudiadas de plantaciones de almendros naturalizadas y la zona de huertos. Los valores de la abundancia representan promedios (± DE) de los siete muestreos. Ap. Plantaciones de almendros naturalizadas; Ga. Área de huertos.

	Ap	Ga
Total species richness	29	20
Bird abundances	23 ± 16.5	30 ± 22.3
Perching birds	10.4 ± 9.6	3.6 ± 2.9
Foraging birds	6.8 ± 6.9	10.7 ± 19.2

with human–modified habitats. Barn swallows are well–adapted to nesting and breeding around human habitation in Catalonia (Estrada et al., 2004) and they are associated with feeding in open farmland areas (Cramp, 2000). Tree sparrows and European serins are granivorous species and are associated with farmland and gardens within the study area (Estrada et al., 2004).

Bird communities recorded in the naturalized almond plantation with scattered Mediterranean vegetation were species–rich, but observed in lower abundance and greater evenness than the communities in the newly established allotments. These findings indicate that newly established allotments of this type provide resources that benefit a few particular species, while adjacent naturalized almond plantations hold a set of resources, mainly related to their vegetation structure (*e.g.*, closed canopy, understory, forest edges, and open herbaceous patches), that support a higher number of more evenly distributed bird species.

As the recently established garden in this study comprises a managed system with constant anthropogenic input of resources it is not unusual that we found significantly higher bird abundance here. These findings are consistent with previous studies that report higher bird abundances in human–altered systems when compared to those from pre–existing wildlands (*e.g.*, forest edges, agro–ecosystem, urban areas; Farina, 1997; Clergeau et al., 1998; Sallabanks et al., 2000; Chace & Walsh, 2006; Ortega–Álvarez & MacGregor–Fors, 2009, in press.). Such increases in bird abundance in human–managed systems have been related to the constant availability of food due to the steady input of resources, but only those species able to exploit these resources benefit (Shochat, 2004; Robb et al., 2008).

The fact that we found a significantly higher number of birds perching in naturalized almond plantations could be related to higher predation risk in open areas (Whittingham & Evans, 2004), and/or the fact that close–canopy habitats with native understory include more perching sites (Guevara et al., 1998). Conversely, we recorded a significantly

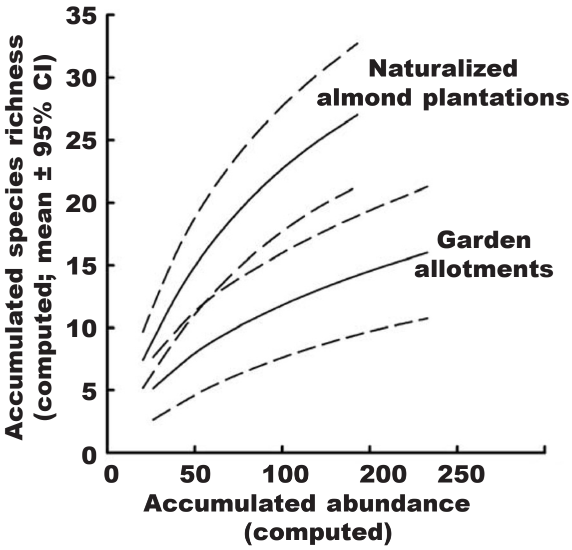

Fig. 2. Rarefaction curves for the naturalized almond plantations and garden allotment area. Bird species richness was significantly higher in naturalized almond plantations, with an average value almost two fold higher than that recorded for the garden allotments. Solid lines represent mean values of species richness and dashed lines 95% confidence intervals.

Fig. 2. Curvas de rarificación para las plantaciones de almendros naturalizadas y la zona de huertos. La riqueza de especies de aves fue significativamente mayor en las plantaciones naturalizadas de almendros, con un valor promedio de casi el doble que las observadas en la zona de huertos. Las líneas continuas representan los valores medios de la riqueza de especies y las líneas discontinuas los intervalos de confianza del 95%.

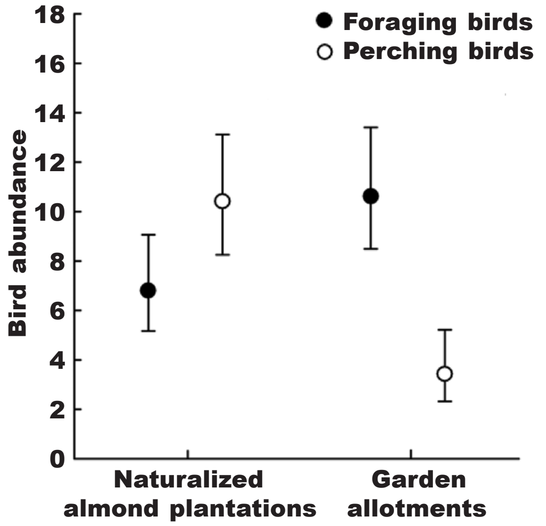

Fig. 3. Habitat use of birds in the naturalized almond plantations and garden allotment area. We found a significantly higher number of birds perching in naturalized almond plantations but a significantly higher number of birds foraging in the garden allotment area.

Fig. 3. Uso del hábitat por parte de las aves en las plantaciones de almendros naturalizadas y la zona de huertos. Encontramos un número de aves significativamente mayor de aves posadas en las plantaciones de almendros naturalizadas, pero un número significativamente más alto de aves forrajeando en la zona de huertos.

higher number of bird foraging in the garden allotments, reinforcing the idea that shifts in the surveyed bird communities are not related to the diversity of food resources present in the two habitats, but to their availability and/or abundance (Shochat, 2004; Robb et al., 2008).

Our results show that the establishment of garden allotments can dramatically shift the diversity and structure of bird communities in a small geographic area. Although our survey shows that bird species richness in the studied area was enhanced ~15% due to the establishment of the garden allotments, adding five new indigenous bird species, four of them (*i.e.*, *Sylvia melanocephala, Lanius meridionalis, Fringilla coelebs, Carduelis cannabina*) were recorded in low numbers (0.15–0.30 individuals/survey) and are common in Mediterranean vegetation matrixes. Thus, not recording a significant effect between the establishment of the studied gardens and regional bird species richness differs from previous studies that have found habitat heterogeneity to increase regional wildlife species richness (Benton et al., 2003; Brotons et al., 2003; Weibull et al., 2003). As the addressed land–use change was of a particularly local nature it is not representative of all possible anthropogenic land–use changes in the region. Further studies are needed to clarify the effects that different types of agricultural systems, developed at different scales and intensities, can have on wildlife communities.

Acknowledgments

We specially thank Jordi Ballesta (SEO/Birdlife Catalunya) for suggesting this study and for allowing the use of field data. Sergi Herrando, Rubén Ortega–Álvarez and two anonymous reviewers kindly improved our manuscript. This study was developed as a collaboration with members of the 2009 SGR 1467 research group.

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