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Effects of land use on nocturnal birds in a Mediterranean agricultural landscape

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Abstract. Knowledge on the effects of land use on community composition and species abundance is crucial for designing realistic conservation strategies, particularly in highly dynamic systems such as Mediterranean agricultural mosaics that are subjected to intensive cultivation. We investigated these effects on the nocturnal bird species occurring in the study area (Stone Curlew *Burhinus oedicnemus*, Red-necked Nightjar *Caprimulgus ruficollis*, Barn Owl *Tyto alba*, Eurasian Scops Owl *Otus scops*, Little Owl *Athene noctua*, Tawny Owl *Strix aluco*, Long-eared Owl *Asio otus*, Short-eared Owl *Asio flammeus* and Eagle Owl *Bubo bubo*) across an agricultural-natural habitat mosaic in Central Spain for three consecutive years. Shares of vineyards, scrubland, herbaceous cropland, water bodies, and roads significantly affected the composition of the nocturnal bird community. Herbaceous cropland and olive groves, which covered 50% of the study area, proved to be neutral for all species. Remnant patches of natural and semi-natural scrubland (around 10% of the study area) and water bodies (only 1.5% of the study area) showed a positive effect on Eagle Owls, Eurasian Scops Owls, Long-eared Owls, and Red-necked Nightjars. Vineyard (35% of the study area) had a negative influence on Eagle Owls, Long-eared Owls, and Eurasian Scops Owls. Our results indicate, first, that the relative extent of land use types was apparently not related with the presence of nocturnal bird species and, second, that natural scrublands and water bodies are key habitats for assuring the persistence of nocturnal birds in agricultural Mediterranean landscapes. Current land planning focused toward land use intensification will likely increase the areas of habitats that are neutral or have adverse effects on nocturnal birds.

Key words: agricultural intensification, agricultural landscape, farmland, population conservation, owl, nightjar, Stone Curlew

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INTRODUCTION

The type of land use strongly affects bird community composition and species abundance (Coppedge et al. 2001, Benton et al. 2002, Webb et al. 2007). This effect might be particularly important in agricultural landscapes, as they are often heterogeneous and dynamically managed as a consequence of the farming practices (Meeus et al. 1990, Llausas et al. 2009). Land planners and conservation practitioners need guidance on effective ways to reconcile retention or enhancement of biodiversity in farming systems while maintaining economic productivity (Haslem & Bennett 2008, Rey Benayas et al. 2008). This may be challenging in landscapes subjected to rapid agricultural intensification, which has been repeatedly shown to be a major cause of species decline (Benton et al. 2003, Fox 2004, Wretenberg et al. 2007, Firbank et al. 2008). Mediterranean climates can make this challenge more difficult as a consequence of their characteristic extreme events (severe droughts and heat waves) which may affect habitat suitability for species (Saether et al. 2004, Giorgi & Lionello 2008).

Most of the species addressed in this study are regionally threatened or representing declining populations (BirdLife International 2004).

Whereas several studies have addressed the relationships between nocturnal bird species and habitat preferences (e.g., Martinez et al. 2003, Martinez & Zuberogoitia 2004, Martinez et al. 2007), there are few studies on the relationships between various coexisting nocturnal bird species and habitat types (Vrezec & Tome 2004, Rey Benayas et al. 2010). Some nocturnal raptors have the additional value of being specialized rodent predators, thus being useful to farmers (Mikkola 1983). Previous results on the same study area indicated that strictly space-dependent habitat features are more critical for explaining spatial patterns than time-dependent factors, such as weather (Rey Benayas et al. 2010).

In the present study, we aim to investigate the effects of land use type on the composition and abundance of a nocturnal bird assemblage across an agricultural-natural habitat mosaic in a Mediterranean landscape. Specifically, we ask the following questions: 1) what land use types are preferably selected by the species?, and 2) is this selection consistent across years of contrasting climate conditions and across seasons?

MATERIALS AND METHODS

Study area

We studied five adjacent 10x10 km squares (500 km^2 in total) located in La Mancha, central Spain (38°46′48″N, 3°15′05″E), during three consecutive years (2005–2007). The altitude ranged between 678 and 1013 m asl. The area is a representative mosaic of different crops and semi-natural or introduced woody vegetation that are characteristic of large extents in Mediterranean landscapes. Croplands were mostly occupied by herbaceous crops (wheat and barley), harvested once a year in June, and permanent woody crops (olive trees — three to five meters high, and vineyards — 1 m high). Natural vegetation mostly consisted of Holm Oak *Quercus rotundifolia* woodland and riparian forests that have been mostly extirpated from this region. As in many other Mediterranean landscapes, the agricultural land is subjected to intensive management (e.g., irrigation of vineyards and olive groves) and land use change, including herbaceous croplands abandonment and afforestation with the native pine *Pinus halepensis* (relative extent of land use types are reported below). Climate in the region is dry continental Mediterranean, with cold winters and warm dry summers. For the years that our bird survey spanned, precipitation in the first six months of each of the three years (when surveys were carried out) was 174, 394 and 439 mm, and the mean temperatures were 15.1, 15.7 and 14.9°C, respectively (averaged data from the three Instituto Nacional de Meteorología climate stations in the area). As compared to the average climate conditions in the region for a 30 year reference period (average precipitation for that period was 410 mm and temperature was 16°C), years can be considered as follow: year 2005 was "very warm" and "very dry", year 2006 was "extraordinarily warm" and of "normal precipitation", and year 2007 was "warm" and "wet" (labels according to Instituto Nacional de Meteorología).

Nocturnal bird survey

Nine nocturnal bird species — Stone Curlew *Burhinus oedicnemus*, Red-necked Nightjar *Caprimulgus ruficollis*, Barn Owl *Tyto alba*, Eurasian Scops Owl *Otus scops*, Little Owl *Athene noctua*, Tawny Owl *Strix aluco*, Long-eared Owl *Asio otus*, Short-eared Owl *Asio flammeus* and Eagle Owl *Bubo bubo* — may potentially occur in the study area. Conservation status in the European Union-25 was "vulnerable" for Stone Curlews, "declining populations" for Barn Owls, Little Owls and Short-eared Owls, and "depleted population" for Eurasian Scops Owls (Birdlife International 2004). However, conservation status is evaluated as "Least Concern" for all species according to Birdlife International (2011), though populations of most species are suspected to be in decline (www.birdlife.org). The nocturnal bird assemblage was surveyed on each 10x10 km square at 13 homogeneously distributed point counts (65 points in total; modal distance between two proximate point counts 2.85 km; min. 2.0 and max. 3.2 km). This variation was consequence of the inaccessibility of several points counts that were moved to the closest reachable location (always at < 0.5 km of distance from the original point). We rotated the direction of travel along survey points to reduce the bias of bird activity. Our survey site density is high even for the smallest species surveyed (two and a half higher than recommended by the survey protocol of the SEO/BirdLife Noctua Program for long-term monitoring of nocturnal birds; http://www.seo.org/). Every counting point was surveyed three times per year, winter (1–15 February), early spring (15–30 April), and late spring (20 May–8 June) for the three consecutive years. For a survey day, the first survey point started right after sunset and the entire survey lasted for three hours. A point count was surveyed for 15 minutes every time. Our survey time was 2,925 minutes per year. We waited for five minutes before resuming counting birds at each point to leave birds to get used to human presence. The same four trained observers in nocturnal bird identification (visual and vocal) conducted the point counts.

We assessed the relative abundance of some owl species in all sites by using taped playback of con-specific natural vocalizations according to the courtship phenology of the species: Tawny Owl and Eagle Owl in winter; Little Owl, Long-eared Owl, Barn Owl and Short-eared Owl in early spring; Eurasian Scops Owl, Little Owl, Barn Owl and Short-eared Owl in late spring. Taped playbacks were not used for Stone Curlew and Red-necked Nightjar because they were easy to detect without stimulation. The vocalization sequence followed an increasing species size to minimize the effects on detection of inter-specific competition and predation (Crozier et al. 2006). The taped vocalization of every surveyed species (maximum of four in early and late spring) was played for two minutes and followed by two minutes for bird response detection at each site.

Auditory detection of nocturnal birds depended on the species, the topography, vegetation, and wind conditions. We recorded auditory and visual contacts of every detected nocturnal bird. Most of the recorded individuals (71.2%) were deemed as territorial individuals since they showed a clear behavior of territory defense, such as a response to taped vocalization, approach to the tape recorder, response to other individuals, and repeated vocalizations. We used the maximum abundance recorded at each point count for each species in all statistical analyses (Melles et al. 2003). Species recorded three or fewer times (Tawny Owl and Short-eared Owl) in the whole survey were not considered further in the analysis. We recorded 658 nocturnal bird contacts during the whole survey — overall, 11 from Barn Owls, 303 from Little Owls, 12 from Long-eared Owl, 30 from Eagle Owls, 165 from Eurasian Scops Owls, 65 from Stone Curlews and 64 from Red-necked Nightjars.

Land use types

Land use types were identified by using aerial ortophotos taken in spring 2003 and digitized within 1 km radius buffer-rings surrounding each point count using ArcGIS 9.0 (ESRI Inc.) One km radius was used to ensure all detected birds were included within the buffer-ring. On each buffer-ring, the percentage of land area occupied by every land use type was obtained. On each buffer-ring, a 2 km transect including 44 homogeneously distributed points was identified by direct observation in 2008 to assess the discrepancy between the observed land use types in the field and the land use types identified by means of aerial ortophotos.

Major land use types included dry herbaceous cropland (39.7% of the total land area), vineyard (34.9%), olive grove (11.6%), scrubland (9.9%) and water bodies (1.5%). We identified ten additional land use types, namely, wooden grassland (i.e., grassland with scattered trees), grassland (including abandoned cropland), orchard, pine plantation, orchard-vineyard, urban, roads, and buildings, each representing between 0.1 and 1% of the total area. It was found that 85% of the ortophoto identification coincided with the field observations.

Statistical analyses

We first used Spearman's rank correlations to assess pair-wise associations between the abundance of bird species and the extent of land use types. We performed multivariate statistics with two groups of variables (species as dependent variables and habitat types — explanatory variables), namely Semi-parametric Permutational Multivariate Analysis of Variance (PERMANOVA; Anderson 2001) and Redundancy Analyses (RDA), to highlight the effects of land use types on the surveyed nocturnal bird community. PERMANOVA has provided robust explanations of bird community-land use relationships previously (e.g. Filloy et al. 2010). This analysis was performed with R statistical software (R Development Core Team 2010) and the 'vegan' package (Oksanen et al. 2011). RDAs has been successfully used for explaining habitat preferences by bird species (e.g. Stillman & Brown 1994, Knick & Rotenberry 2000). RDA models were calculated at three levels; they related the relative extent of land use types to the maximum abundance of every species observed: (1) along the complete study period (the general model), (2) each year of the study period (the inter-annual model), and (3) each weather season (the seasonal model). Due to highly frequent zero values in the data (i.e., species not occurring at a particular point count), a Chord transformation was used (Zuur et al. 2007). Only land use types with a significance < 0.05 in the Monte Carlo permutation test were considered for RDA. Only the model with the highest sum of canonical eigenvalues was selected. To estimate the contribution of every explanatory variable to the model, single conditional effects were obtained. We used the arcsine transformation of the percentage of land area occupied by every land use type at each point count to avoid the unit-sum constrains. RDA was performed using CANOCO for Windows 4.5 (Biometrics-Plant Research International). Two sites where none species occurred were not considered in any multivariate analysis.

RESULTS

Shares of vineyard, scrubland, roads, and water bodies significantly correlated ($p < 0.05$) with three or more bird species (see Appendix 1). Vineyard was positively correlated with the abundance of Stone Curlew and negatively correlated with the abundance of Eagle Owl, Long-eared Owl, and Eurasian Scops Owl. Scrubland was positively correlated with Eagle Owl, Eurasian Scops Owl, Long-eared Owl, and Red-necked Nightjar. Roads showed negative correlations with Little Owl, Eagle Owl, and Eurasian Scops Owl. Water bodies were positively correlated with Red-necked Nightjar, Long-eared Owl, and Eurasian Scops Owl.

Five land use types, which represented 29.3% of total variation, were found to significantly affect the species composition of the nocturnal bird assemblage according to the PERMANOVA. In decreasing order of importance, they were vineyard, wooden grassland, herbaceous cropland, water bodies, and roads (Table 1). RDA for the general model that analyzed the complete study period showed positive linear relationships between the abundance of Eagle Owl and scrubland, Eurasian Scops Owl and water bodies, and Stone Curlew and vineyard (Fig. 1, Table 2). Negative linear relationships were found between Eagle Owl and Eurasian Scops Owl and vineyard, and between Eurasian Scops Owl and roads (Fig. 1).

The land use types preferred by different species were basically consistent across the study years (i.e., the position of the same species recorded at different years in the ordination biplot are close; Fig. 2). Only scrubland and water bodies showed significant linear relationships with bird species in the seasonal model. The preferred habitats exhibited by the different species were mostly consistent across the study seasons (i.e. winter, early spring, and late spring; Fig. 3). However, this model suggests different habitat preferences by Red-necked Nightjar in early spring and late spring.

DISCUSSION

We assessed the effects of land use type on the composition and abundance of nocturnal birds across an agricultural-natural habitat mosaic dominated by herbaceous and woody crops in a representative Mediterranean landscape. Our results

Table 1. Land use types explaining variation in nocturnal bird composition — results of the PERMANOVA analysis. Land use types are listed in decreasing order of explained variation.

Land use type	df	Sum of squares	R^2	F-statistic	p-value
Vineyard	1	1.3295	0.12231	9.9791	0.001
Scrubland	1	0.5934	0.05460	4.4543	0.001
Herbaceous cropland	1	0.5523	0.05081	4.1457	0.002
Water bodies	1	0.3834	0.03528	2.8781	0.024
Roads	1	0.3275	0.03013	2.4585	0.034
Olive grove	1	0.2387	0.02196	1.7920	0.129
Orchard	1	0.2425	0.02230	1.8198	0.155
Grassland	1	0.1758	0.01617	1.3193	0.229
Wooded grassland	1	0.1691	0.01556	1.2694	0.303
Buildings	1	0.1536	0.01413	1.1529	0.336
Vineyard-orchard	1	0.1150	0.01058	0.8628	0.483
Urban area	1	0.1083	0.00996	0.8126	0.564
Pine plantation	1	0.0857	0.00788	0.6433	0.629
Residuals	48	6.3951	0.58833		
Total	62	10.8699	1.00000		

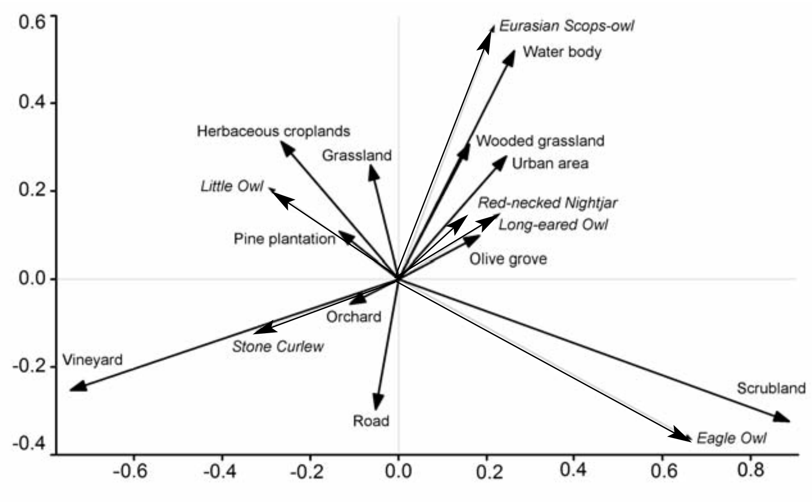

Fig. 1. RDA ordination biplot relating the maximum abundance of nocturnal bird species observed along the complete study period (2005–2007; the general model) and selected land use types. Variance explained: $\lambda_1 = 44.1$ and $\lambda_2 = 28.6$. Sum of all canonical eigenvalues = 0.24.

highlight that the relative importance of land use types to explain the species variation of this assemblage is not related to their extent, and provide further evidence of the importance of natural and semi-natural habitats for wildlife conservation, particularly birds, in farmland landscapes (Heikkinen et al. 2004, Haslem & Bennett 2008). We also found overall consistency of land use types as factors explaining community composition in years of contrasting weather conditions and of habitat preferences in different seasons.

Habitat preferences

Remnant patches of Mediterranean scrubland (9.9% of the study area), had a positive effect on nocturnal bird abundance and richness in this study. The presence of patches of natural or semi-natural vegetation within an agricultural matrix is a well-known issue for the conservation of diurnal bird communities (Heikkinen et al. 2004, Laiolo 2005, Johnson et al. 2007, Billeter et al. 2008, Haslem & Bennett 2008) and, consequently, it was expected to have a similar positive effect on the studied nocturnal birds. Specifically, scrubland was the most important land use type for Eagle Owl since it contains the rocky sites needed to nest and it is the optimum habitat of its major prey, the European Rabbit *Oryctolagus cuniculus* (Martinez et al. 2003, Penteriani et al. 2004). Scrubland also favored the presence of Eurasian Scops Owl (the most endangered owl in Europe; BirdLife International 2004, 2011) and Red-necked Nightjar. A high availability of food resources and the presence of trees to nest, only in the case of the Eurasian Scops Owl, might explain this preference (Rodriguez et al. 2006, Martinez et al. 2007). Water bodies (1.5% of the study area) positively affected the abundance of Eurasian Scops Owl and Red-necked Nightjar. The presence of this habitat type in dry agricultural environments might provide an enhanced primary productivity and resource availability, especially of insects, that might attract those insect consumers (Mendelsohn et al. 2007, Schneider & Griesser 2009).

Vineyard (34.9% of the study area) had contrasting effects on the abundance of particular species. Eagle Owl, Long-eared Owl, and Eurasian Scops Owl avoided this habitat in the

Table 2. Conditional effects for the selected Redundancy Analysis models.

Land use type	Increase of the total sum of eigenvalues	F-statistic	p-value
Scrubland	0.09	6.58	0.005
Vineyard	0.05	3.27	0.010
Herbaceous cropland	0.04	3.27	0.015
Roads	0.04	2.53	0.040
Olive grove	0.03	2.28	0.045
Orchard	0.02	2.04	0.055
Pine plantation	0.02	1.35	0.230
Wooded grassland	0.01	1.11	0.360
Water bodies	0.02	1.04	0.400
Grassland	0.00	0.55	0.685
Urban area	0.00	0.12	0.995

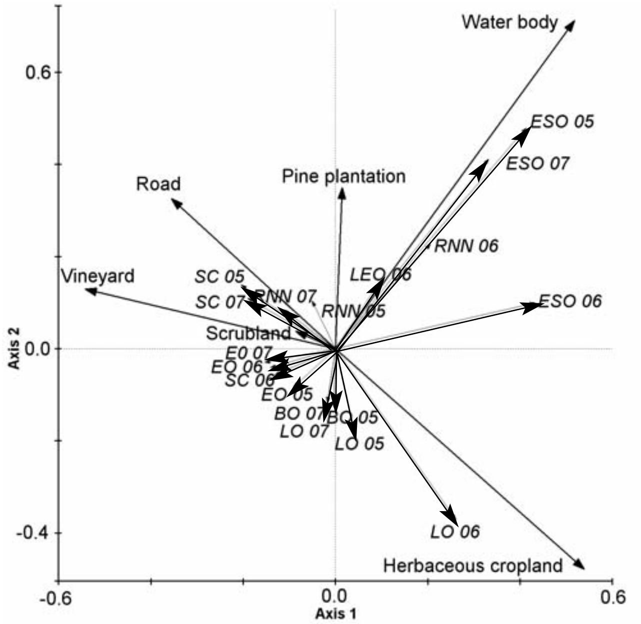

Fig. 2. RDA ordination biplot relating the maximum abundance of nocturnal bird species observed each year of the study period (the inter-annual model) and selected land use types. Variance explained: $\lambda_1 = 38.0$ and $\lambda_2 = 29.3$. Sum of all canonical eigenvalues = 0.20. Species are labeled by their initials followed by the study year.

study area. Other studies have shown that some woody crops can be poor breeding habitats for bird communities in other Mediterranean regions because of their regular mechanical (ploughing and pruning) and chemical treatments. These agricultural treatments may exert a negative effect on herbaceous plants and rodent and insect populations, hence reducing feeding opportunities and favoring the secondary intoxication of bird populations (Brakes & Smith 2005, Laiolo 2005). However, Stone Curlew apparently preferred vineyards. Since this species nests and feeds on the ground, and has a preference for flat woodless areas with scattered bushes (Martí & Moral 2003), this is an unexpected result that may require further verification.

The dominant land use type in the studied region, i. e. herbaceous cropland (39.7% of the surface), which substantially explained assemblage species composition, was not significantly related with the presence of any particular species. Differently from other studies where positive relations were reported between share of olive groves and Little Owl (Martinez & Zuberogoitia 2004, Martinez et al. 2007), we found olive groves (11.6% of the surface) functioning as a neutral habitat for the nocturnal bird species under study.

Temporal variation

Habitat selection across years and seasons of contrasted weather conditions was mostly consistent. Habitat features that are strictly space-dependent are more critical for explaining the documented assemblage patterns than other factors that change over time such as weather (Rey Benayas et al. 2010). We found, though, that species that predate on invertebrates showed a trend to select different habitats in the extraordinarily warm year than in the two other years. This may be attributed to prey fluctuation of these species (Williams 1961), as we did not find changes in habitat selection of species feeding on larger preys (Valkama et al. 2005).

Conservation implications

The critical importance of patches of natural and semi-natural habitats at the landscape scale has been demonstrated in this and other studies (Johnson et al. 2007, Haslem & Bennett 2008). Particularly, we encourage land-managers to preserve and create abundant and dense "islets of natural vegetation in agricultural seas", to conciliate agricultural production and biodiversity conservation (Rey Benayas et al. 2008). Existing water bodies, some of them artificial and frequently used in agricultural intensification projects, must

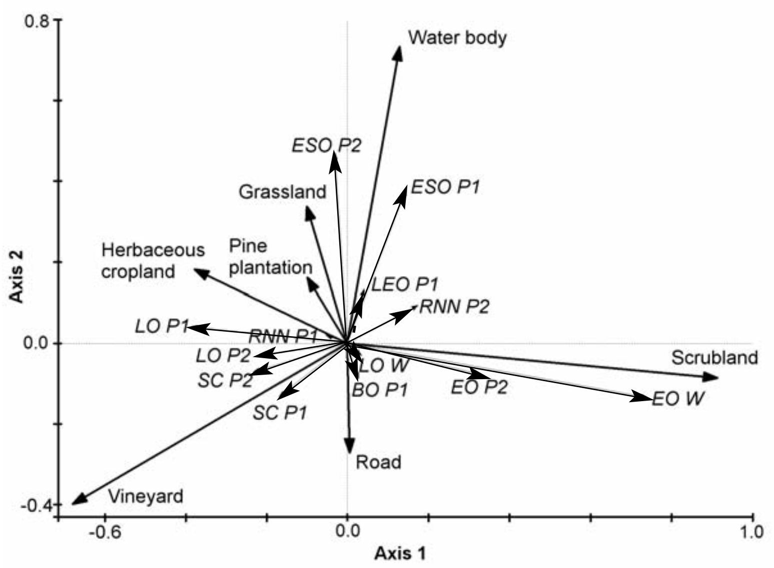

Fig. 3. RDA ordination biplot relating the maximum abundance of nocturnal bird species observed on each weather season (the seasonal model) and selected land use types. Variance explained: λ_1 = 41.3 and λ_2 = 24.2. Sum of all canonical eigenvalues = 0.19. Species are labeled by their initials followed by the season (W — winter, P1 — mid spring, P2 — late spring).

be maintained and adapted for their use by nocturnal birds (e.g. by making the water accessible to potential preys, small birds, micro-mammals, and insects, or by establishing nearby tree vegetation to allow nocturnal birds' nesting, hiding, roosting, and hunting; Michelat & Giraudoux 2000, Martinez et al. 2007). The negative effect of roads on some nocturnal bird species found in this study and other studies (Martinez & Zuberogoitia 2004, Martinez et al. 2007, Palomino & Carrascal 2007) might be reduced by detecting critical points of nocturnal bird mortality and using barriers to avoid the entrance of micro and mesomammals and amphibians to the road (Dodd et al. 2004, Woltz et al. 2008). Finally, future research is needed on how neutral habitats for some species can be adapted to host stable populations of these species.

CONCLUSIONS

Our results indicate that natural scrublands and water bodies (10% of the study area) are key habitats to be conserved or restored for assuring the persistence of nocturnal birds in agricultural Mediterranean landscapes. Large portions of the territory (~ 50%; olive groves and herbaceous croplands) act as neutral habitats to nocturnal bird communities. Roads (< 0.5% of the study area) have negative effects on some species. Vineyards (35% of the study area) are a management challenge as they might favor some species but damage others. Weather conditions during different years and seasonality have little or none effect on the spatial distribution and habitat preferences of the studied nocturnal bird assemblage. During the current agricultural intensification, land-planners must focus efforts to increase the cover of natural habitats, protect existing water bodies, and reduce the use of road surroundings by birds to increase biodiversity and the associated benefits of nocturnal birds to farmers.

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STRESZCZENIE

[Wpływ sposobu użytkowania gruntów na ptaki o aktywności nocnej w śródziemnomorskim krajobrazie rolniczym]

Dane prezentujące związek pomiędzy składem zespołów i liczebnością poszczególnych gatunków ptaków a sposobem gospodarowania ziemią są kluczowe zarówno dla tworzenia strategii ochronnych jak i planów zagospodarowania przestrzennego.

W pracy badano związek pomiędzy użytkowaniem gruntów a występowaniem i liczebnością dziewięciu gatunków ptaków o aktywności nocnej: kulona, lelka rdzawoszyjego, płomykówki, syczka, pójdźki, puszczyka, uszatki, uszatki błotnej i puchacza. Prace prowadzono przez trzy kolejne lata (2005–2007) na pięciu powierzchniach 10×10 km (łącznie 500 km^2) położonych w mozaice środowisk w środkowej Hiszpanii. Występowanie ptaków badano metodą punktową (13 punktów/powierzchnię), każdy punkt był odwiedzany trzykrotnie w ciągu sezonu — zimą, wczesną i późną wiosną. Pojedyncza kontrola trwała 15 min., posługiwano się stymulacją magnetofonową. Za każdym razem głosy ptaków odtwarzane były w kolejności zwiększających się rozmiarów ciała poszczególnych gatunków. Nie wykorzystywano stymulacji w przypadku kulona i lelka. Dla każdego punktu, w którym wykonywane były kontrole opisano procentowy udział poszczególnych siedlisk w promieniu 1 km. Wyróżniono następujące siedliska: uprawy (głównie pszenica i jęczmień), winnice, gaje oliwne, zarośla krzewiaste i zbiorniki wodne. Prócz tego wydzielono jeszcze: drogi, sady, obszary zurbanizowane, zadrzewione łąki i nasadzenia sosnowe, których udział nie przekraczał 1% opisywanej powierzchni (aneks 1). Uzyskane wyniki dotyczące ptaków (wykorzystując do analiz maksymalną stwierdzoną liczebność) powiązano następnie z udziałem poszczególnych sposobów użytkowania powierzchni, zarówno dla wszystkich danych łącznie, jak i dla każdego okresu fenologicznego i roku osobno (ponieważ warunki klimatyczne — tj. temperatura i opady, różniły się pomiędzy latami).

Udział winnic, zarośli krzewiastych, upraw, zbiorników wodnych i dróg istotnie wpływały na cały zespół badanych ptaków, jak i na poszczególne gatunki (Tab. 1, aneks 1). Tereny upraw i gajów oliwnych, które łącznie zajmowały blisko 50% badanego terenu zostały uznane za neutralne dla badanych gatunków. Udział pozostałości naturalnych i półnaturalnych zarośli krzewiastych oraz zbiorników wodnych pozytywnie wpływał na puchacza, syczka, uszatkę i lelka rdzawoszyjego (Fig. 1, Tab. 2). Udział winnic i dróg negatywnie wpływał m. in. na puchacza, syczka i uszatkę (Fig 1). Natomiast udział winnic pozytywnie wpływał na liczebność kulona (Fig. 1). Stwierdzone zależności między liczebnością ptaków a sposobami użytkowania gruntów były podobne dla poszczególnych lat (Fig 2) i okresów fenologicznych (Fig. 3), choć w tym ostatnim przypadku stwierdzono różnice w preferencjach lelka rdzawoszyjego wczesną i późną wiosną.

W badanym krajobrazie rolniczym klimatu śródziemnomorskiego tereny o charakterze naturalnym oraz zbiorniki wodne mają kluczowe znaczenie dla badanych gatunków. Problem z punktu widzenia ochrony gatunków mogą stanowić winnice, których powierzchnia wpływa pozytywnie na liczebność niektórych, a negatywnie na inne gatunki. Niestety obecny system zagospodarowania przestrzennego, skupiający się na intensyfikacji rolnictwa prowadzi do zwiększania powierzchni neutralnych lub negatywnie wpływających na liczebność badanej grupy ptaków.

Appendix 1. Spearman's correlation coefficients between the proportion of land use types and the maximum abundance of birds detected for every species. The last row indicates the proportional area of every land use type with respect to the total area studied. Correlations were performed for each year and for the maximum abundance of all three years. Significant correlations coefficients at $p < 0.05$ and significant relations at $p < 0.1$ are shown. ‡ — $p < 0.1$, * — $p < 0.05$, ** — $p < 0.01$, *** — $p < 0.001$.

	Year	Herbaceous cropland	Vineyard	Olive grove	Scrubland	Water bodies	Pine plantations	Wooden grassland	Urban	Roads	Orchard
Stone curlew	2007		0.343**						‡		
	All		0.367**								
European Scops Owl	2005				0.368**	0.288*	‡	0.266*		-0.258*	
	2006		-0.291*		0.380**	‡	‡	0.316*			-0.273*
	2007		-0.251*		0.375**	‡	‡	0.355**		-0.309*	
	All		-0.334**		0.399***	0.248*		0.395**		-0.261*	
Long-eared Owl	2005		-0.255*								
	2006		-0.288*		0.259*	‡					
	2007					‡					
	All		-0.368**		0.281*	0.291*					
Eagle Owl	2005				0.270*						
	2006		-0.385**		0.384**					‡	
	2007		-0.436***		0.436***					‡	
	All		-0.393**		0.472***					-0.268*	
Red-necked Nightjar	2005					‡				‡	
	2006				0.368**	0.325**					
	2007				‡			0.370**			‡
	All			0.249*	0.296*	0.346**					
Barn Owl	2006								0.304*		
Little Owl	2006								‡	-0.277*	
	2007	0.270*								-0.364**	
	All								-0.264*	-0.280*	
Area (%)		39.7	34.9	11.5	9.89	1.54	0.59	0.48	0.44	0.32	0.18