Reptile assemblages across agricultural landscapes: where does biodiversity hide?

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Abstract

Reptile assemblages across agricultural landscapes: where does biodiversity hide?— The transition from traditional to intensive farming, aimed at large–scale production, has rapidly altered agricultural landscapes, leading to the reduction and fragmentation of natural habitats and to the consequent loss of biodiversity. Herpetofauna is seriously threatened by agriculture intensification worldwide, but less is known about its distribution in agro–ecosystems, especially at field scale. We analysed reptile abundance and diversity in eight agricultural and semi–natural land uses, and inside vegetated buffer strips interspersed among fields. Interestingly, most reptiles were recorded in the buffer strips while intensive crops and pastures hosted just one lizard species. Richness of individuals and species increased when strips were connected to semi–natural areas, independently of their width and vegetation structure. In view of our results, that highlight the role of minor landscape features for the presence of vertebrates in intensive agro–ecosystems, we recommend the implementation of buffer strips among the measures for vertebrate conservation in agricultural landscapes.

Key words: Agriculture, Biodiversity, Buffer strips, Herpetofauna, Reptiles

Resumen

Comunidades de reptiles en paisajes agrícolas: ¿dónde se esconde la biodiversidad?— La transición de la agricultura tradicional a la intensiva, orientada a la producción a gran escala, ha alterado rápidamente los paisajes agrícolas, lo que ha conllevado la reducción y fragmentación de los hábitats naturales y la consiguiente pérdida de biodiversidad. La herpetofauna está gravemente amenazada por la intensificación agrícola en todo el mundo, pero se sabe poco acerca de su distribución en los ecosistemas agrícolas, especialmente a escala local. Se analizaron la abundancia y la diversidad de reptiles en ocho usos del suelo agrícolas y seminaturales, así como dentro de parches de vegetación intercalados entre cultivos. Curiosamente, la mayoría de los reptiles se observó en los parches de vegetación, mientras que en los cultivos intensivos y los pastos solo se encontró una especie de lagarto. La riqueza de individuos y de especies aumenta cuando los parches de vegetación están en contacto con zonas seminaturales, independientemente de la anchura y la estructura de la vegetación de estas. En vista de los resultados obtenidos, que ponen de relieve la influencia de las características del paisaje de menor importancia en la presencia de vertebrados en los ecosistemas agrícolas intensivos, recomendamos incluir parches de vegetación como medida de conservación de los vertebrados en los paisajes agrícolas.

Palabras clave: Agricultura, Biodiversidad, Parches de vegetación, Herpetofauna, Reptiles

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Introduction

Human activities deeply alter the environment, creating novel habitats and inducing reduction, fragmentation and even loss of the pre–existing habitats. These processes clearly have serious consequences on many organisms, and understanding how anthropic pressure influences the distribution, the population dynamics and the ecology of other species is a fundamental step for conservation. Over the last decades, in most agricultural regions in Europe, there has been a transition from local subsistence farming to more industrial cultivation practices aimed at large–scale production. Intensively cultivated fields have rapidly expanded, leading to the drastic reduction and fragmentation of patches of natural and semi–natural vegetation, and to the creation of more uniform landscapes. Intensive agriculture is largely accepted today as one of the major causes of large–scale biodiversity loss (Wake, 1991; Foley et al., 2005).

Reptiles are among the taxa that are primarily threatened by land use changes, habitat fragmentation (Heyer et al., 1994; Gibbons et al., 2000) and, particularly, by the expansion of intensive agriculture, worldwide (Glor et al., 2001; Ribeiro et al., 2009). Due to their ecological and physiological features, relatively low dispersal ability, and small home ranges, reptiles are sensitive even to local habitat changes (Díaz et al., 2000; Driscoll, 2004) and they thus suffer from the consequences of landscape changes more than other vertebrates (White et al., 1997). In the Mediterranean regions, reptiles make up a high portion of the vertebrate fauna in terms of biomass, and they play a key role in ecosystem balance because of their intermediate position in the food web (Rugiero & Luiselli, 1995; Martín & López, 1996; Padilla et al., 2005, 2007; Pérez–Mellado et al., 2008).

For such reasons, reptiles can be particularly suitable to detect the consequences of human–induced land use changes on biodiversity. Nevertheless, studies on the effects of intensification of agricultural practices on vertebrates rarely focus on reptiles (but see, for example, Driscoll, 2004; Berry et al., 2005; Ribeiro et al., 2009), concentrating mostly on birds (Donald et al., 2001; Verhulst et al., 2004; Atkinson et al., 2005; Wretengerger et al., 2006), or mammals (Smith et al., 2005; Heroldová et al., 2007). On the other hand, herpetofauna is more often embraced in conservation programs and therefore, knowledge of the distribution of amphibian and reptile species inside agro–ecosystems is key to designing effective conservation strategies and agronomic measures aimed at mitigating the effects of intensive management.

In this paper we analysed reptile assemblages in an area mainly devoted to agriculture and dominated by intensively cultivated arable lands. To see how reptiles are distributed in such a landscape, we surveyed and compared reptile abundance and diversity in some agricultural and semi–natural land uses, and also inside vegetated buffers interspersed among crops, namely strips of vegetation along ditch banks and field margins (*sensu* Greaves & Marshall, 1987). Buffer strips may represent key elements in agro–ecosystems because of their role in mitigating against intensive management practices, providing multiple services for water and soil quality (Lynch et al., 1985; Osborne & Kovacic, 1993; Marshall & Moonen, 2002; De Cauwer et al., 2005), and also for invertebrate diversity (Sotherton, 1985; Wratten, 1988; Lagerlöf et al., 1992; Blake et al., 2011; Simão et al., 2015). However, little is known about the role of vegetated buffers in the conservation of vertebrate fauna, particularly regarding small mammals and reptiles (Marshall, 2002). Moreover, given their small extension, these linear landscape elements are neglected in most studies on biodiversity, especially when made at a regional scale and based on land cover databases.

Material and methods

Study area and sampling method

The study was performed in central Italy (45° 42' 49.30'' N, 11° 06' 43.46'' E), in an area (of about 400 km^2) mainly devoted to agriculture, with non–irrigated arable lands covering about 64% of the surface, and broad–leaved forests covering about 20% (Corine Land Cover categories) (fig. 1). The altitude of study sites varied from 0 to 180 m a.s.l. To detect reptile abundance and diversity, we performed transects in eight different agricultural (Agr, both crops and pastures) and semi–natural (SNat) land uses, distributed in 31 sites (each including only one land use): broadleaved woodlots (Wo), pinewoods (Pw), sand dune habitats (S), olive orchards with intensive (O) and traditional (Ot) managements, arable lands (A), vineyards (V), pastures (Pa) (fig. 1, table 1 for details). We also surveyed vegetated buffer strips (Bs), linear strips of semi–natural, unmanaged vegetation, which cross the matrix of cultivated lands (table 1). Transects are a quick and effective method to survey reptiles (Latham et al., 2005; Urbina–Cardona et al., 2006); they are particularly practical when sampling more sites in a wide area, and in agricultural lands they allow minimum disturbance to management activity (Paggetti et al., 2006). We walked at constant speed along linear paths, recording every reptile encounter within 1 m on both sides of the observer. Transects were 100 m long on average and were at least 20 m away from one another to prevent multiple recording of the same individual; each transect was replicated twice. Sampling was performed during May and June 2009.

Statistical analyses

In order to analyse the patterns of reptile abundance and diversity across the sampled land uses, we considered three variables: the number of individuals in 100 m (Nind), the number of species in 100 m (Nsp, considered as a rough index of species diversity), and the Shannon–Wiener index of study sites (H, Shannon & Weaver, 1948). To calculate Nind and Nsp, we used data from single transects. To assess H values, for each land use, we considered the total

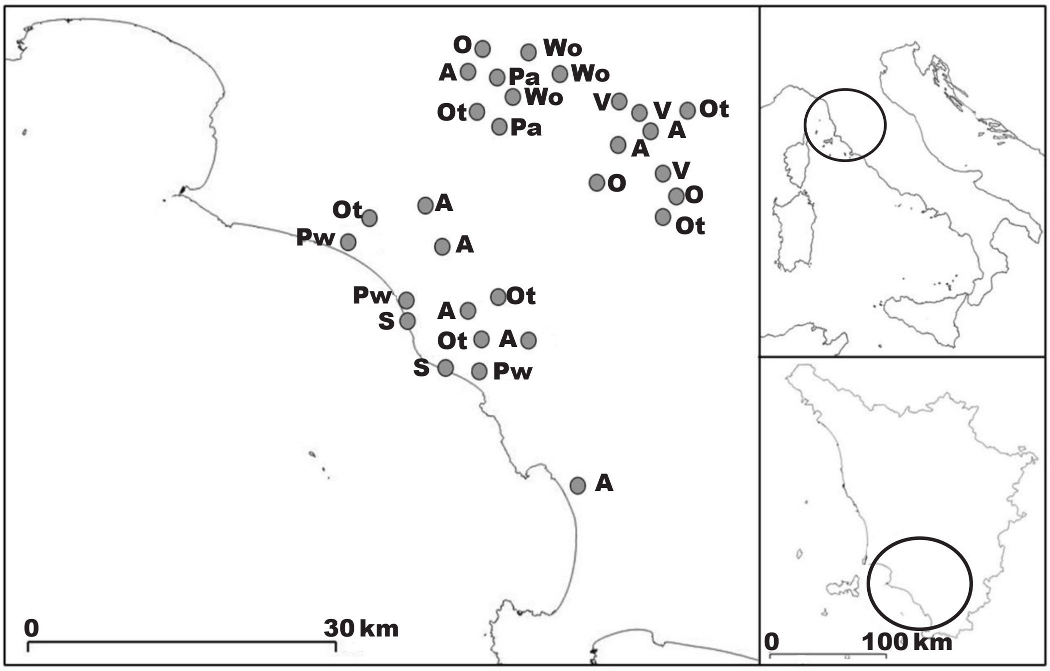

Fig. 1. Location of the 31 study sites (on the left) and position of the study area at national (top right) and regional scale (bottom right). (For abbreviations see Material and methods and table 1.)

Fig. 1. Ubicación de los 31 sitios de estudio (a la izquierda) y situación de la zona de estudio a escala nacional (arriba a la derecha) y a escala regional (abajo a la derecha). (Para las abreviaturas ver Material and methods y tabla 1.)

number of individuals observed in the different study sites, while BS transects were grouped in relation to the land uses which they adjoined (*i.e.,* Bs bordering A). We then considered the following environmental variables: study site area (Area); study site edge density (ED, perimeter/area), an indicator of spatial heterogeneity, taking into account the shapes of patches (EEA, 2000; Walz, 2011); and vegetation structure (VEG). Considering that we mainly dealt with ground dwelling reptiles, transects were classified in two VEG categories on the basis of the ground vegetation structure of the land uses they belonged to: i) VEG1, ground vegetation absent or made up exclusively by herbaceous species; ii) VEG2, presence of shrubs. To each buffer strip (Bs) transect we associated three environmental variables: i) vegetation structure (VEG1, VEG2); ii) average width of buffer strips (W, the average value of three measures taken at the beginning, in the middle, and at the end of each transect); iii) degree of connectivity, indicating whether strips were connected to semi–natural areas (*i.e.,* woodlots or wetlands with a minimum area of 300 ha) (CON1, not connected; CON2, connected with one semi–natural area; CON3, in connection with more semi–natural areas). Width of buffer strips, area, edge density, and connectivity of buffer strips were assessed using Geoportale Nazionale orthophotos and tools (www.pcn.minambiente.it).

We tested the number of individuals (Nind) and species (Nsp) for spatial autocorrelation, using Moran's values obtained at 10 different distance intervals. To verify how abundance of individuals and species varied in the study area, we compared Nind and Nsp, first among Agr and SNat categories (agricultural and semi–natural lands) and Bs (buffer strips), then among the eight land uses and Bs. Owing to the large number of transects with no observations, Nind and Nsp were not normally distributed even after log–transformation (Kolmogorov–Smirnov, n = 204: Nind, χ^2 = 100.109, p < 0.001; Nsp, χ^2 = 109.388, p < 0.01). For this reason, we used log–linear models, assuming a Poisson distribution of the data (Sutherland, 2006; Wilson et al., 2007). Multiple comparisons of mean rank were then applied (Siegel & Castellan, 1988). Such analyses were applied to all the following comparisons. To test the possible influence of vegetation structure on reptile abundance, we compared Nind and Nsp between VEG categories in Agr and in SNat. In the eight land uses, we also tested the possible influence of study site Area and ED (edge density) on the mean values of the number of individuals (Nind) and number of species (Nsp), and on the Shannon–Wiener index (H), performing Spearman correlations. We also compared H values among land use categories Agr, SNat, and Bs (while the number of study sites per land use was

Table 1. List of surveyed land uses (L) and their main environmental features, categories (Categ), VEG category, number of transects (Nt) and study sites (Ns); the total number of recorded species (Nsp) and mean values (± SD) of reptile abundance (Nind), species abundance (Nsp), and diversity (H) are also reported. Land uses: Wo. Broadleaved woodlots; Pw. Pinewoods; S. Sand dune habitats; O. Olive orchards; Ot. Traditional olive orchards; A. Arable lands; V. Vineyards; Pa. Pasture; Bs. Buffer strips. Categories: Agr. Agricultural; SNat. Semi–natural.

L	Categ	VEG	Nt	Ns	Descriptive notes
Wo	SNat	2	18	3	Mainly oak (*Quercus* sp.) forests, natural or partially managed
Pw	SNat	1	13	4	*Pinus pinaster* forests along the coast. A Few herbaceous species under trees
S	SNat	2	10	2	Coastal sand dunes. Sparse vegetation essentially made up of grasses
O	Agr	1	13	3	Olive tree (*Olea europaea*) plantations, intensively managed. Use of chemicals and machinery, ploughed soil, and almost absent grass
Ot	Agr	2	27	6	Olive tree (*O. europaea*) plantations with 'traditional' management: maintenance of soil cover (mainly herbaceous species but also sparse bushes), scarce or absent use of machinery
A	Agr	1	27	8	Mainly cereal and alfalfa fields
V	Agr	2	24	3	Mainly intensively managed vineyards (*Vitis vinifera*). Use of chemicals and machinery, ploughed soil
Pa	Agr	1	11	2	Lowland meadows (with very low diversity of grass species) and pastures devoted to pig farming
Bs	–	–	61	–	Semi–natural strips of vegetation bordering agricultural lands: strips of riparian vegetation along ditches and banks of small rivers and field margins. Mean width ranging from 2 to 19 m; varying vegetation structure

too low to allow the comparison of H among land uses). Focusing on buffer strips (Bs), we compared Nind and Nsp in CON and VEG categories in order to verify the possible influence of connectivity and vegetation structure on abundance of reptiles and species. Finally, we tested the influence of Bs width (W) on Nind and Nsp using Spearman correlation.

We used Statistica 10.0 (StatSoft, Inc., 2011) for all the analyses, except for spatial autocorrelation analysis performed by PAST 2.17b package (Hammer et al., 2001).

Results

During sampling of transects we recorded a total of 278 individuals belonging to seven reptile species: *Chalcides chalcides* (23), *Lacerta bilineata* (15), *Podarcis muralis* (29), *P. siculus* (206), *Hierophis viridiflavus* (4) and *Vipera aspis* (1).

Spatial autocorrelation did not affect the patterns of abundance observed (of both individuals and species) (fig. 2). Reptile abundance (Nind) differed among land use categories, with agricultural land uses (Agr) hosting the lowest number of reptiles, significantly lower than buffer strips (Bs) (table 2, fig. 3). The comparisons among land uses showed that arable lands and intensively managed olive orchards (A and O) hosted the lowest number of reptiles, significantly differing, in particular, from buffer strips (Bs) (see table 2 for other significant results, figs. 3, 5). Nind also varied significantly between VEG categories: both agricultural and semi–natural land uses with a simplified ground vegetation (absent or made up of just herbaceous species) were significantly poorer in numbers of reptiles than land uses where shrubs were also present (table 2, fig. 3). Finally, in Agr land uses, mean Nind was negatively correlated with field Area ($n = 22$, $r = –0.506$, $p = 0.019$) and increased with increasing edge density (ED) ($n = 22$, $r = 0.528$, $p = 0.014$). In SNat land uses, mean Nind did not co-

Tabla 1. Lista de los usos agrícolas estudiados (L) y sus principales características ambientales, categorías (Categ), categoría VEG, número de transectos (Nt) y de áreas estudiadas (Ns); también se muestran el número total de especies observadas (Nsp) y los valores medios (± DE) de la abundancia de reptiles (Nind), de la abundancia de especies (Nsp) y de la diversidad (H). Usos del suelo: Wo. Bosques de frondosas; Pw. Pinares; S. Hábitats de dunas; O. Olivares; Ot. Olivares tradicionales; A. Tierras arables; V. Viñedos; Pa. Pastos; Bs. Parches de vegetación. Categorías: Agr. Agrícola; SNat. Seminatural.

Nsp	Mean Nsp (± SD)	Mean Nind (± SD)	Mean H (± SD)
4	0.603 ± 0.682	0.977 ± 1.286	1.068 ± 0.359
1	0.267 ± 0.438	0.344 ± 0.625	0
2	0.615 ± 0.569	1.705 ± 1.307	0.161 ± 0.227
1	0.077 ± 0.277	0.077 ± 0.277	0
4	0.561 ± 0.677	0.805 ± 1.034	0.215 ± 0.577
1	0.053 ± 0.275	0.106 ± 0.550	0
1	0.343 ± 0.626	0.438 ± 0.729	0
1	0.303 ± 0.674	0.455 ± 1.078	0
5	0.926 ± 1.122	1.864 ± 2.227	0.888 ± 0.800

rrelate with Area (*n* = 9, *r* = 0.350, *p* = 0.359) and ED (*n* = 9, *r* = 0.317, *p* = 0.385).

The analyses of diversity across land uses gave results analogous to those concerning reptile abundance. In agricultural (Agr) land uses, we recorded the lowest number of species (Nsp), significantly different from that recorded in buffer strips (Bs), the land use with the highest Nsp values (table 2, fig. 4). Arable lands and intensively managed olive orchards (A and O) hosted the lowest number of species (table 2, fig. 4). Agricultural land uses with more complex vegetation structure had significantly higher Nsp values, while in SNat we recorded no differences among VEG categories. As observed for reptile abundance, in Agr land uses Nsp was negatively correlated with field Area (*n* = 22, *r* = –0.462, *p* = 0.035), and positively correlated with edge density (ED) (*n* = 22, *r* = 0.486, *p* = 0.026). In SNat land uses, we did not find correlations between Nsp and Area (*n* = 9, *r* = –0.050, *p* = 0.880) and ED (*n* = 9, *r* = 0.133, *p* = 0.708).

The comparison of the Shannon index (H) among land use categories confirmed that levels of biodiversity in Agr land uses were significantly lower than those recorded in Bs (table 2). Considering cultivated lands, H was different from zero only in traditional olive orchards (Ot) (table 1). H was not influenced by site Area and ED either in Agr (*n* = 22: Area, *r* = –0.111, *p* = 0.633; ED, *r* = –0.110, *p* = 0.632) or in SNat (*n* = 9: Area, *r* = –0.438, *p* = 0.269; ED, *r* = 0.310, *p* = 0.422).

Focusing on buffer strips (Bs), we found that abundance of reptiles and species did not differ significantly between vegetation categories (table 2), and they were not correlated with buffer width (*n* = 61: Nind, *R* = 0.178, *p* = 0.177; Nsp, *R* = 0.147, *p* = 0.266). On the contrary, both Nind and Nsp varied in relation to connectivity: buffer strips characterized by the lowest connectivity level hosted significantly fewer individuals and species than buffer strips connected with at least one semi–natural area (table 2).

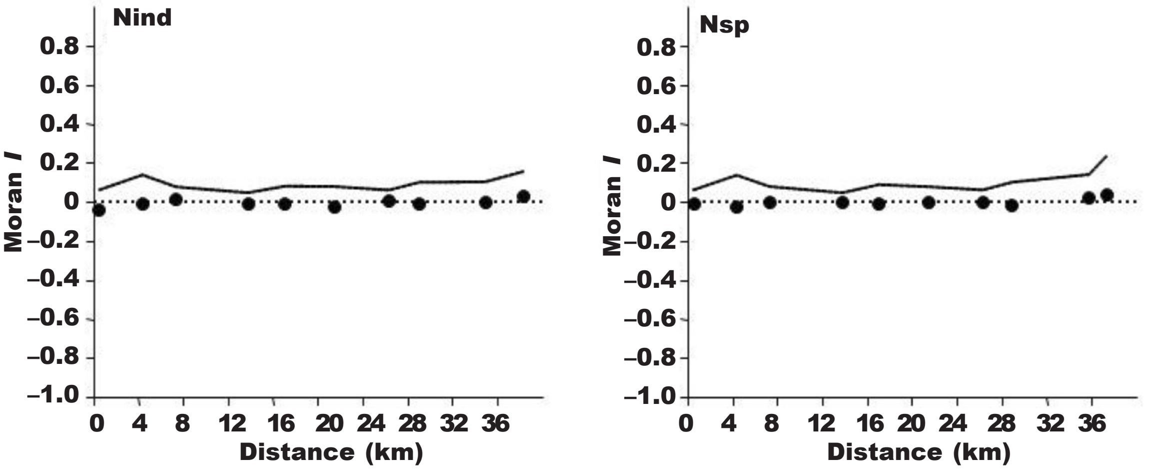

Fig. 2. Moran's *I* correlograms for number of individuals (Nind) and number of species (Nsp). Circles are non–significant values, continuous lines indicate *P* critical value (0.05).

Fig. 2. Correlogramas de Moran I *para el número de individuos (Nind) y el número de especies (Nsp). Los círculos representan los valores no significativos y las líneas continuas indican el valor crítico P (0,05).*

Discussion

In most European countries, traditional agricultural landscapes, typically characterized by mosaic–like structures, intermediate levels of disturbance, and able to host great biodiversity levels (Bignal & McCracken, 1996), have undergone profound transformations in last decades. The rapid extension of intensively cultivated fields and the reduction and fragmentation of the original habitats have led to the creation of more uniform and depleted landscapes, with significant loss of biodiversity (Whittaker, 1975; Bull & Skovlin, 1982; Burel et al., 1998; Zechmeister & Moser, 2001; Moser et al., 2002; Pfiffner & Luka, 2003). In accordance with these changes, our analysis of reptile assemblages in an agricultural area mainly devoted to the intensive cultivation of arable lands found the landscape to be relatively poor in biodiversity. Four out of five agricultural land uses hosted only one species, while most of the recorded reptiles occurred inside a few patches of semi–natural habitats and, above all, in the grid of vegetated buffer strips interspersed among the cultivated lands. In addition, during field activity, we observed only seven of the eighteen species of terrestrial reptiles reported for the province where the sites are located, and most records were ascribable to a single species.

Specifically, we recorded an overriding presence of the lacertid lizard *Podarcis siculus* (Italian wall lizard), which greatly influenced the patterns of reptile abundance and diversity here described. *P. siculus* was the only species present in all the surveyed land uses, particularly including all the cultivated lands. A large diffusion of this lizard in the study area is partly ascribable to the ecological requirements of the species that prefers flat, relatively open habitats (Corti et al., 2010). However, the striking differences in the distribution and abundance of *P. siculus* with respect to all the other species go beyond mere considerations on habitat preference. In general, in the presence of human–induced landscape alterations, most species can be disadvantaged if suitable conditions for their ecological requirements persist only in fragments of natural habitats (Doak et al., 1992; Bender et al., 1998; Laurance et al., 1998). However, it can also happen that some species benefit from the novel habitat matrix (Laurance et al., 2002; Cardador et al., 2011). This could be the case of *P. siculus* that, at least to a certain extent, is probably able to resist land use transformations or even to take advantage of the expansion of cultivated lands, open and often depleted areas where other species cannot persist. On the other hand, the low number of species that we recorded could also be partly due to the sampling method: transecting is particularly efficient for detecting species like lizards but it could be less suitable for others, also in relation to the surveyed environments (McDiarmid et al., 2012). However, the gap between the species observed and those potentially present in the area is so wide that it could indicate a real lack, likely related to the scarce availability of suitable habitats.

With the data at our disposal, we identified two main categories of land uses: those characterized by conditions apparently adverse to reptiles, where just one species could be observed or it clearly prevailed on the others, and the few land uses in which more species occurred and faunal composition was better balanced (table 1, fig. 4). Almost all cultivated plots, that represented the environmental matrix of the area, belonged to the former category: with the only exception of traditionally managed olive orchards, where

Table 2. Results of comparisons of reptile abundance (Nind) and diversity (Nsp and H) among land use categories (Agr and SNat) and buffer strips (Bs), land uses and Bs, vegetation categories (VEG), and connectivity levels (CON) (just for Bs transects).

Tabla 2. Resultados de la comparación de la abundancia de reptiles (Nind) y la diversidad (Nsp y H) entre el uso agrícola (Agr), el uso seminatural (SNat) y los parches de vegetación (Bs); entre el conjunto de todos los usos del suelo y los Bs; entre las categorías de estructura de la vegetación (VEG), y entre los grados de conectividad (CON) (solo para los transectos en los Bs).

Variable	Comparisons	n	Wald χ^2	p	Multiple comparisons
Nind					
	Agr/SNat/Bs	Agr = 112; SNat = 41 Bs = 61	72.977	< 0.001	Agr < Bs, SNat
	All land uses and Bs	See table 1	74.248	< 0.001	A, O < Bs, S, V < Bs
	VEG in Agr	VEG1 = 51; VEG2 = 51	11.606	< 0.001	–
	VEG in SNat	VEG1 = 13; VEG2 = 28	6.484	0.011	–
	VEG in Bs	VEG1 = 33; VEG2 = 28	0.165	0.684	–
	CON in Bs	CON1 = 13; CON2 = 30; CON3 = 18	12.395	0.002	CON1 < CON2, CON3
Nsp					
	Agr/SNat/Bs	Agr = 112; SNat = 41; Bs = 61	27.379	< 0.001	Agr < Bs, SNat
	All land uses and Bs	See table 1	29.085	< 0.001	A, O < Bs
	VEG in Agr	VEG1 = 51; VEG2 = 51	9.065	0.002	–
	VEG in Snat	VEG1 = 13; VEG2 = 28	1.940	0.164	–
	VEG in Bs	VEG1 = 33; VEG2 = 28	0.054	0.816	–
	CON in Bs	CON1 = 13; CON2 = 30; CON3 = 18	10.581	0.005	CON1 < CON3
H					
	Agr/SNat/Bs	Agr = 22; SNat = 9; Bs = 6	9.715	0.008	Agr < Bs

four reptile species were detected, agricultural lands hosted just one lizard species (*P. siculus*). The most exacerbated situation was observed inside arable lands, where lizards occurred exclusively near field margins and never in the middle of crops, as noticed in other agricultural areas (pers. obs.; Biaggini et al., 2011). Although specific studies should be performed to strengthen these observations (Kéri, 2002), our data suggest that the extension of fields negatively influenced abundance of both individuals and species, while increasing edge density supported higher values of the two variables. Moreover, a more complex vegetation structure enhanced reptile diversity and abundance, as found in other Mediterranean agricultural landscapes (Germano & Hungerford, 1981; Martín & López, 2002). All these observations further stress how the occurrence of very large monocultures (especially of arable lands) can negatively impact on reptiles in agricultural landscapes.

Higher complexity of reptile communities, in terms of both diversity and abundance, subsisted in semi–natural patches (especially in broadleaved woodlots). The importance of such patches has also been largely demonstrated for vascular plants, birds and arthropods (*i.e.,* Billeter et al., 2008). More interestingly, vegetated buffer strips mostly contributed to enhance fauna richness in the surveyed agricultural landscape, showing the highest levels of reptile diversity and abundance among the analysed land uses. The importance of these linear landscape features for increasing biodiversity in rural landscapes dominated by intensive managements has been already stressed with regards to flora (Barr et al., 1993), invertebrates (Sotherton, 1985; Wratten, 1988; Lagerlöf et al., 1992), mammals (Pollard & Relton, 1970; Boone & Tinklin, 1988; Fitzgibbon, 1997; Verboom & Huitema, 1997), and birds (O'Connor, 1987; Lack, 1992; Vickery & Fuller, 1998), but not for reptiles. Interestingly, neither the complexity of vegetation structure nor strip width were crucial to determining the presence of reptiles inside buffer strips. This was in contrast with results found in both agricultural and semi–natural land uses, where vegetation structure played a role in shaping reptile presence. On the contrary, the factor that significantly influenced abundance of individuals

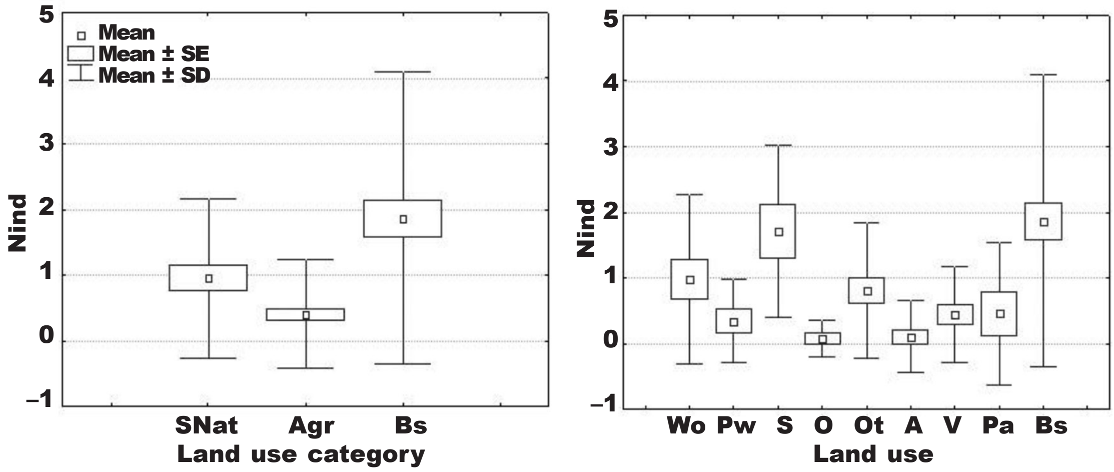

Fig. 3. Reptile abundance (Nind) in the surveyed land use categories (left) and land uses (right), and buffer strips (Bs) (box–plots show mean value ± SD).

Fig. 3. Abundancia de reptiles (Nind) en las categorías de usos del suelo (izquierda) y los usos del suelo (derecha) estudiados, así como en los parches de vegetación (Bs) (los diagramas de cajas muestran la media ± DE).

and species inside buffer strips was their degree of connectivity. Namely, the presence of reptiles was minimal in those strips that were not in connection with any semi–natural area. All these observations suggest that reptiles do not settle in buffer strips but exploit them as temporary refuges while foraging at crop margins or during displacements (Madsen, 1984; Wisler et al., 2008). Usually, both vegetation structure and strip width are key factors for animal groups, like invertebrates, that steadily inhabit these strips of vegetation (De Cauwer et al., 2005). Specific studies are obviously required to disclose the way in which reptiles exploit buffer strips. However, the grid made up of field borders and strips of riparian vegetation along watercourses may allow reptiles to penetrate the 'barrier' of intensive crops and to

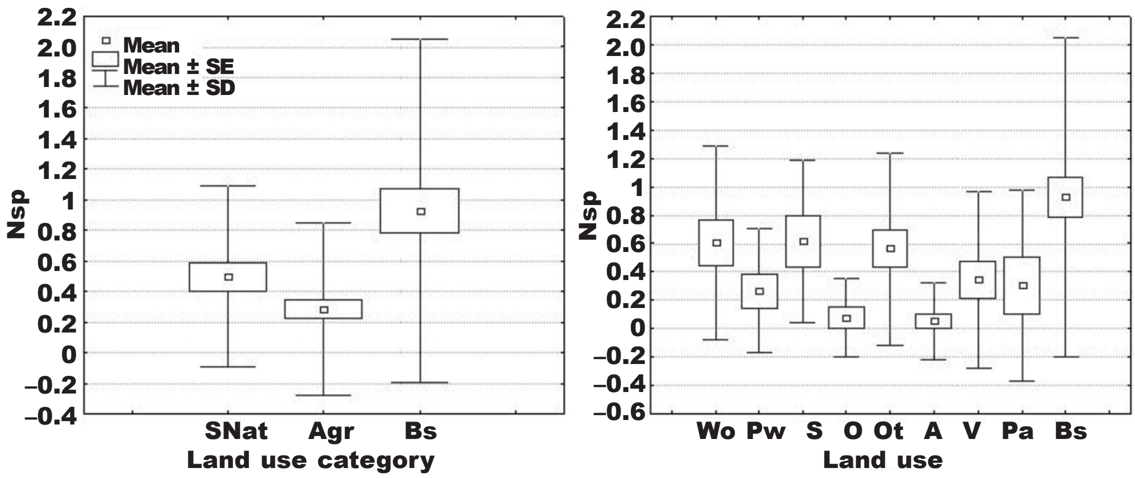

Fig. 4. Number of species (Nsp) in the surveyed land use categories (left) and land uses (right), and Bs (box–plots show mean value ± SD).

Fig. 4. Número de especies (Nsp) en las categorías de usos del suelo (izquierda) y los usos del suelo (derecha) estudiados, así como en los Bs (los diagramas de cajas muestran la media ± DE).

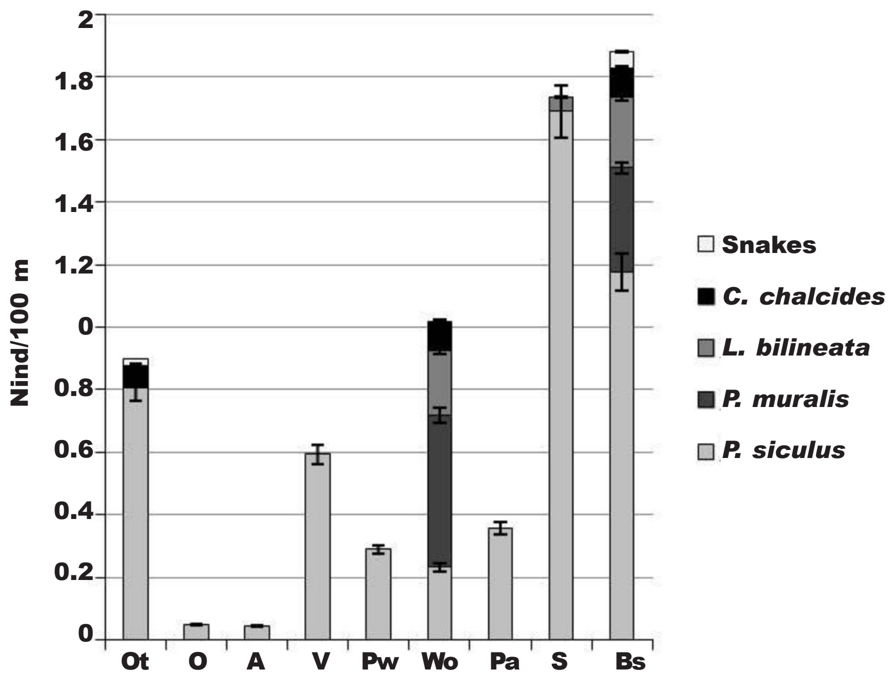

Fig. 5. Reptile abundance and fauna composition in the surveyed land uses (columns indicate the mean number of reptiles in 100 m, grey tones indicate the different species, and bars indicate 5% errors).

Fig. 5. Abundancia de reptiles y composición faunística en los usos del suelo estudiados (las columnas indican el número medio de reptiles en 100 m, los tonos grises indican las diferentes especies y las barras, el 5% de error).

disperse among cultivated areas. Thanks to their relatively thick vegetation, buffer strips probably represent the safest crosswalk available in intensive agricultural landscapes. Accordingly, the role of field margins and riparian strips in supporting fauna movement across cultivated lands has previously been observed for invertebrates (Burel, 1989), bats (Verboom & Huitema, 1997) and birds (Machtans et al., 1996). In such a perspective, buffer strips would play a key ecological function, considering that the presence of a matrix of unsuitable habitats can represent, in some cases, a selective filter for species throughout the landscape (Gascon et al., 1999) and can prevent dispersion of individuals and gene flow (Wilcove et al., 1986).

Focusing on the analysis of reptile assemblages, our study confirms that in landscapes dominated by intensive agriculture (mainly arable lands) biodiversity is low and concentrated in a few, less managed, landscape features. In general, analyses made at a regional scale individuate such features in patches of semi–natural vegetation with quite large surfaces (*i.e.,* woodlot, wetlands) or, at least, in wide vegetated river banks. Interestingly, working at field scale allowed us to highlight the key importance of 'minor' landscape features for the presence of vertebrates in agro–ecosystems, namely strips of riparian vegetation along the banks of ditches and small rivers, and field borders. Even if relatively narrow and simple in their vegetation structure, these linear features can greatly contribute to the presence of reptiles in agro–ecosystems (especially when in connection with semi–natural patches), and they probably play a key ecological role in allowing dispersal of individuals and species across intensive crops. On the other hand, the absence of reptiles inside intensively managed plots clearly points to the need for mitigation measures aimed at enhancing vertebrate diversity in agricultural landscapes. We strongly recommend the implementation of a grid of vegetated buffer strips together with conservation of the remaining semi–natural patches among the measures for biodiversity conservation in agro–ecosystems.

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