Volume 31 (April 2021), 77-84

Herpetological Journal FULL PAPER

https://doi.org/10.33256/31.2.7784

Published by the British Herpetological Society

Occurrence of lizards in agricultural land and implications for conservation

Marta Biaggini[1] & Claudia Corti[1]

[1] Museo di Storia Naturale, Università degli Studi di Firenze, Sede "La Specola", Via Romana 17, 50125 Firenze, Italy

Agriculture intensification is among one of the major threats affecting terrestrial reptiles worldwide. There is however a lack of information available on the ecology of these vertebrates in agricultural landscapes. Basic information like the pattern of occurrence in cultivated fields is key to assess the probability of an animal being affected by threats driven by agricultural managing. Focussing on the Italian wall lizard (*Podarcis siculus*), we performed a field study to assess in detail its distribution and abundance in two cultivations, vineyards and cereal fields. Lizard distribution and abundance significantly varied among land uses, regardless of the arthropod fauna composition and diversity (analysed in the same fields), and the management activities. In the cereal fields, lizards were present exclusively along the field margins while in the vineyards they also occurred in the inner portions of the cultivated areas, even if they were more abundant next to the borders. The widespread presence of lizards in the vineyards suggest that *P. siculus* can likely adapt to such cultivated areas. This partly lowers the effect of habitat loss due to vineyard planting but exposes animals to the risks related to management activities, including mechanical practices and chemical application. In contrast, the presence of sowed lands, as extremely simplified habitats, results primarily in a definitive loss of habitat for lizards that are unable to settle within them, while the exposure to threats driven by management is less direct than in vineyards.

Keywords: agriculture, *Podarcis*, reptiles, wildlife protection

INTRODUCTION

Agricultural intensification has widely transformed the traditional agricultural landscapes throughout the European countries, including the Mediterranean region, typically replacing complex and heterogeneous landscapes with simplified and depleted ones (Benton et al., 2003; Tscharntke et al., 2005). Intensively cultivated areas have rapidly expanded to the detriment of patches of natural and semi-natural vegetation, small croplands and ecotones, resulting in habitat loss, landscape uniformisation and becoming the leading cause of biodiversity loss in agroecosystems (Sala et al., 2000).

Agriculture intensification and intensive use of natural resources are among the most common threats affecting terrestrial reptiles worldwide (Gibbons et al., 2000; Todd et al., 2010; Böhm et al., 2013). These vertebrates, usually have relatively small home ranges and a limited dispersal ability (Huey, 1982), thus being directly exposed to the effects of changes in land use and agricultural management. The presence of reptiles (and especially lizards) can play an important ecological role in agro-environments. The diet of these vertebrates, being mainly insectivorous and less often showing specialisation, allows them to survive and attain relatively high densities also in depleted ecosystems (Regal, 1983), as cultivated lands can be, thus providing an important food resource for higher level predators. Consequently, changes in their population densities can have cascading effects on other trophic levels over the long-term (Martín & López, 1996; Díaz et al., 2006). With this perspective in mind, analysing and monitoring lizard distribution and density in agricultural habitats can be of particular interest for wildlife conservation. There is a general lack of information available on the distribution and ecology of reptiles in agricultural landscapes, especially at field scale (but see Wisler et al., 2008; Biaggini et al., 2009; Amaral et al., 2012a; Biaggini & Corti, 2015; Biaggini & Corti, 2017), as well as on the effects of agriculture management on these vertebrates (Driscoll, 2004; Berry et al., 2005). Analysing the occurrence of a species inside agricultural habitats is essential to assess its risk of exposure to possible threats driven by management, such as mechanical activities or a chemicals' application. Indeed, the probability of animals to be exposed to a certain threat mainly depends on the overlap (in time and space) between their presence and the appearance of the threat in the fields (Ockleford et al., 2018).

In this study we analysed, at the field-scale, lizard distribution and abundance inside different agricultural

Correspondence: Marta Biaggini (marta.biaggini@virgilio.it)

land uses, focussing on the Italian wall lizard, *Podarcis siculus* (Rafinesque-Schmaltz, 1810). This species is quite widespread inside agricultural landscapes and, at least to some extent, it is able to adapt to and take advantage of human-altered environments (Biaggini & Corti, 2015; Biaggini & Corti, 2017). In particular, we wanted to determine the actual occurrence of lizards in two cultivations common to central Italy, vineyards and cereal fields, verifying if (and how far) lizards are present inside the cultivated patches or if they occur just along the field boundaries. Moreover, in order to test if food availability could be a driver shaping lizard distribution in the two land uses, we also analysed the arthropod fauna composition and diversity in the same fields.

METHODS

Study species

Podarcis siculus is a medium sized lacertid lizard mainly distributed in Italy, in most of the surrounding islands, and along the eastern coast of the Adriatic Sea. In Central Italy, where the study was performed, *P. siculus* concentrates its annual activity between early spring and late autumn, usually occurs at low elevation, and in open habitats (Corti et al., 2010). When compared with syntopic species, *P. siculus* shows a preference for relatively arid vs. humid microhabitats, both on rocky surfaces and open meadows, avoiding tree cover (Van Damme et al., 1990; Capula et al., 1993).

Study area

The study was performed in an agricultural area in central Italy (43°40’ N, 11°09’ E, total extension = about 280 ha; elevation = 90 – 150 m a.s.l.; annual range of temperature = -0.1 – 35.9 °C; annual precipitation = 620.80 mm), in four vineyards and two cereal fields (Fig. 1). We choose sites lying on the same slope in order to reduce the variability of environmental factors like sun and wind exposure. This choice limited the number of cereal fields available for samplings. On the other hand, due to the irregular shape of the vineyards, for this land use we had to include more than two sites in order to have a sufficient sample of transect segment far from the field margins (> 50 m, see Statistical analyses). Vineyards were characterised by conventional management, including use of chemical compounds and mechanical management activities, while in the cereal fields (that were sowed in the autumn preceding our study) no agricultural practices, including harvest, were performed during our sampling period due to a wildlife management program.

Sampling procedure

In order to record lizard abundance, we performed 103 linear transects (length ranging from 100 to 380 m) covering the surfaces of the four vineyards (76 transects) and the two cereal fields (27 transects). Considering that *Podarcis* lizards usually run distances of less than 3 m while escaping from potential predators (e.g., Rugiero, 1997; Diego-Rasilla, 2003; Biaggini et al., 2009), within

Figure 1. Examples of the surveyed land uses: cereal fields (above) and vineyards (below) during field activity, in May (left) and September (right).

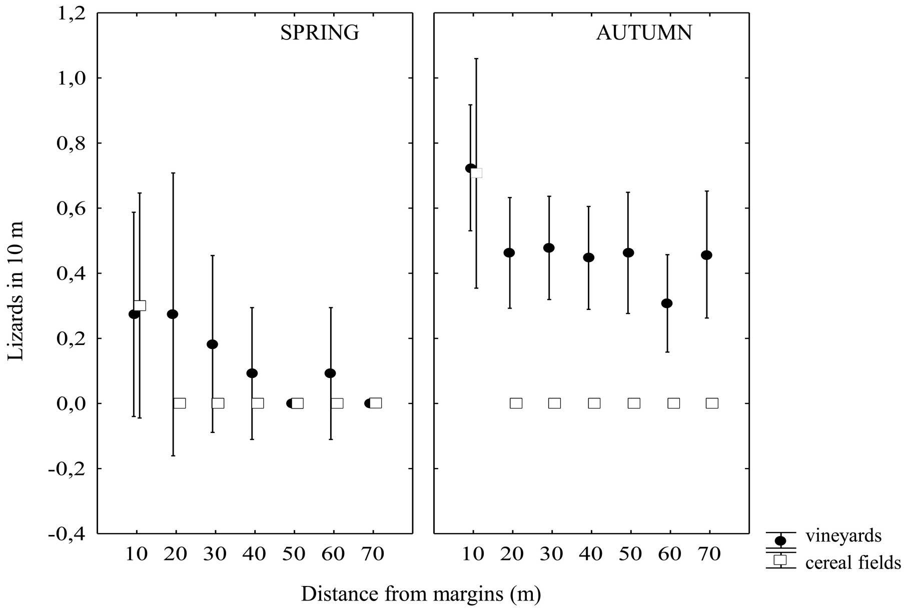

Figure 2. Mean number of lizards observed in 10 m transects' segments at increasing distances from uncultivated field margins, inside vineyards (black circles) and cereal fields (white squares), in spring and autumn.

each site, transects were parallel and more than 15 m far apart one to the other, to prevent multiple recordings of the same individual. Transects were walked in May and September – October 2006, on sunny days between 7:00 and 19:00 h, covering the whole daily activity period of *Podarcis siculus* (Foà et al., 1992). In the same sites we sampled epigeal arthropods, using 28 pitfall traps randomly distributed (16 in the cereal fields, 12 in the vineyards), filled with a solution of vinegar and acetylsalicylic acid. Traps were emptied and replaced once every 14 days from April – July (five sampling periods). This method is particularly suitable for collecting ground-dwelling arthropods (Biaggini et al., 2007) that represent the majority of the diet of *P. siculus* (Pérez-Mellado & Corti, 1993), thus providing information on the potential food availability. All arthropods were identified to the level of order; after identification, specimens were oven dried at 70 °C and for each trap, the content of the single samplings was weighed to the nearest 0.0001 g. In order to further verify a possible correlation between lizard and arthropod fauna presence, we collected data on *P. siculus* density and arthropod fauna diversity in agricultural lands, from papers listed in Table 1 and related databases. All data were gathered with the same techniques used for the present study.

Statistical analyses

We divided each transect into 10 m long segments (667 segments in total) and for each segment we extrapolated the number of lizards observed. In order to analyse lizard abundance, we performed a Generalised Linear Model (GLM) using the number of lizards per segment as the dependent variable (not normally distributed even after log-transformation, Kolmogorov-Smirnov: $n = 667$, $d = 0.415$, $P < 0.01$), land use (vineyards vs cereal fields), distance from the nearest uncultivated margin (from 0 – 10 m to 60 – 70 m) and season (spring vs autumn) as fixed factors.

In order to characterise the superficial arthropod fauna of the study sites, we analysed faunal composition, biodiversity (using the Shannon-Wiener index calculated on arthropod orders, H) and dry weight (as a proxy of biomass). We assessed the pattern of faunal composition among the 28 traps by performing a Principal Component Analysis (PCA) on the relative proportions of arthropods' orders, calculated on the total number of specimens (we arcsine transformed the proportions to avoid the complications present in analysing compositional data). We analysed arthropod diversity and biomass through GLM analyses, using H (Kolmogorov-Smirnov: $d = 0{,}064$, p = n.s.) and the dry weight (Kolmogorov-Smirnov: $d = 0{,}068$, p = n.s.) of single samplings as dependent variables, land use (vineyards vs cereal fields) and distance from the field margin (near if < 10 m; far if > 10 m) as fixed factors. In these analyses we used the 10 m distance from the nearest margin to classify traps as near or far from the border, corresponding to the transect segment giving the strongest results for lizard density. With the aim of further investigating the possible correlation between lizard abundance and arthropod diversity, we performed a GLM on the reference data listed in Table 1, considering lizard density as dependent variable, H index calculated on arthropod orders and season as continuous and categorical predictors, respectively. We used STATISTICA software for all the analyses (StatSoft, Inc., 2011).

RESULTS

The number of lizards observed in 10 m long segments with increasing distance from the margins towards the inside of fields significantly differed among land uses, distances from field margins, seasons and in relation

Table 1. Mean values (± st. dev.) of density of *Podarcis siculus* (N in 100 m) and Shannon-Wiener index of arthropod orders (H) in several agricultural land uses in Italy (months of samplings are indicated in brackets; n.a. = not available). Data were extrapolated from reference papers and related databases (Ref.: present study = p.s.; Biaggini & Corti, 2015 = a; Biaggini et al., 2015a = b; Biaggini et al., 2015b = c; Corti et al., 2015 = d). In italics: data not used in the analyses, here reported to give account of the range of *P. siculus* density in the considered land uses.

Land use	Area, n. of sites	N in 100 m (months)	H (months)	Ref.
Unmanaged olive grove	Sardinia, 1	0 (V-VI); 0.889 ± 1.018 (X)	2.094 ± 0.227 (V-VI); 1.502 ± 0.326 (X)	d
Traditional olive grove	*S Tuscany, 6*	*0.806 ± 0.554 (V-VI)*	*n.a.*	*a*
	Sardinia, 6	0.889 ± 0.565 (III-IV)	2.004 ± 0.369 (III-IV)	b
	Sardinia, 1	3.704 ± 2.313 (V-VI); 9.259 ± 5.481 (X)	2.402 ± 0.404 (V-VI); 2.081 ± 0.217 (X)	d
Conventional olive grove	*S Tuscany, 3*	*0.077 ± 0.277 (V-VI)*	*n.a*	*a*
	Sardinia, 3	0.704 ± 0.539 (III-IV)	2.050 ± 0.384 (III-IV)	b
	Sardinia, 1	1.748 ± 0.780 (V-VI); 2.747 ± 0.780 (X)	1.840 ± 0.592 (V-VI); 1.863 ± 0.114 (X)	d
Vineyard	*S Tuscany, 3*	*0.438 ± 0.729 (V-VI)*	*n.a.*	*a*
	N Tuscany, 4	0.997 ± 0.671 (V); 2.569 ± 1.231 (IX-X)	1.576 ± 0.439 (IV-VI); n.a.	p.s.
Sowable land	*S Tuscany, 8*	*0.106 ± 0.550 (V-VI)*	*n.a.*	*a*
	N Tuscany, 1	0 (IV-VI); 0.079 ± 0.238 (X)	1.797 ± 0.587 (V-VI); 1.776 ± 0.923 (X-XI)	c
	Veneto, 1	0 (IV-VI); 0 (IX-X)	1.487 ± 0.477 (V-VI); 1.228 ± 0.359 (IX-X)	c
Set aside	N Tuscany, 1	0 (IV-VI); 0.180 ± 0.270 (X)	1.817 ± 0.167 (V-VI); 1.935 ± 0.352 (X-XI)	c
	Veneto, 1	0.048 ± 0.167 (IV-VI); 0 (IX-X)	1.480 ± 0.288 (V-VI); 1.151 ± 0.750 (IX-X)	c
Unmanaged sowable land	N Tuscany, 2	0.300 ± 0.483 (V); 0.702 ± 0.323 (IX-X)	2.132 ± 0.270 (IV-VI); n.a.	p.s.

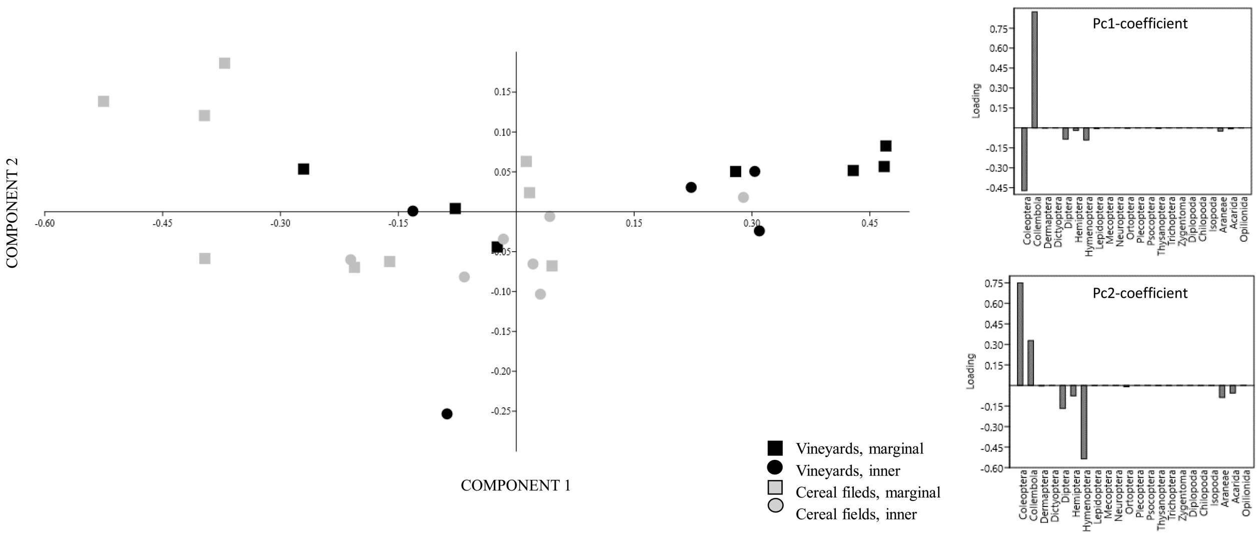

Figure 3. Scatter plot displaying PCA performed on arthropod order composition of the pitfall traps put in vineyards and cereal fields (marginal and inner portions for both land uses are represented).

Table 2. Comparison of lizard density in 10 m transects'segments in relation to the distance from the nearest uncultivated margin (from 0-10 m to 60-70 m), the land use (vineyard vs cereal filed) and the season (spring vs autumn). The number of transects'segments (N) per comparison is shown.

	d.f.	Wald	P	N (tot = 667)
Intercept	1	1388.273	< 0.001	
Distance from margin (1)	6	206.691	< 0.001	10, 20, 30, 40, 50 m = 103; 60 m = 87; 70 m = 65
Land use (2)	1	345.177	< 0.001	Vineyards = 575; Cereal fields = 92
Season (3)	1	36.868	< 0.001	Spring = 140; Autumn = 527
(1)*(2)	6	104.473	< 0.001	
(1)*(3)	6	27.059	< 0.001	
(2)*(3)	1	30.331	< 0.001	
(1)*(2)*(3)	6	31.369	< 0.001	

to the interaction of the three variables (Table 2, Fig. 2). Vineyards hosted more lizards than cereal fields; for both land uses, we recorded the highest number of individuals in the first 10 m from the field margins and higher densities in autumn than in spring. In the cereal fields, we observed lizards exclusively in the first transect segments (0 – 10 m) and, in particular, within 3 m from the margins (personal observations).

We identified 22 orders of arthropods, among which Collembola, Coleoptera, Hymenoptera and Diptera represented 56.5 %, 19.7 %, 10.2 % and 7.1 % of the collected specimens, respectively. Traps from different land uses showed no striking differences in faunal composition; however, traps from the cereal fields were clustered slightly leftmost along the axis of the first principal component (explaining 85 % of variance), with higher relative abundance of Coleoptera and lower abundance of Collembola (Fig. 3). A GLM performed on arthropod order diversity revealed higher values of the Shannon-Wiener index in the unmanaged cereal fields than in the vineyards (n samplings: cereal fields = 74, vineyards = 56; $F = 15.886$, $P < 0.001$), and no significant differences between marginal and inner portions of the fields in both land uses (n samplings: margin = 65, inside = 65; $F = 0.083$, $P = 0.774$). The same analysis performed on the arthropod dry weight revealed no significant differences among land uses ($F = 1.913$, $P = 0.169$) and with varying distances from field margins ($F = 0.313$, $P = 0.577$). Lizard density did not vary in relation to arthropod diversity (n= 18, Wald = 0.121, $P = 0.728$) in spring and autumn (Wald = 0.965, $P = 0.326$) based on the reference data collected in Table 1.

DISCUSSION

Assessing the patterns of occurrence of a species is crucial to identify the major threats suffered by animals and the extent of their exposure to such threats within a certain habitat. In agricultural landscapes, where the demand for effective conservation measures is pressing, such information is very scarce, especially for some vertebrates. We found substantial differences in the distribution of the Italian wall lizard among agricultural land uses. In the cereal fields, lizards were present exclusively in a narrow belt along the field margins while in the vineyards they also occurred in the inner portions of the cultivated areas, though with significantly lower densities than next to the borders (in the first 10 m). In autumn, we recorded the same pattern of distribution than in spring in both land uses, but with higher lizard densities due to the large presence of juveniles (accounting for about 62 % and 68 % of lizards inside cereal fields and vineyards, respectively).

The home range of *Podarcis siculus* covers up to 300 m^2 (Foà et al., 1990; Avery, 1993) and, consequently, most of lizards' activities are probably concentrated in about a 10 m radius around the home range cores. Therefore, lizards recorded in the cereal fields, next to the borders, probably settle in the adjoining habitats. On the contrary, the occurrence of adults and juveniles (performing shorter movements; Braña, 2003) up to 70 m inside vineyards may entail a quite stable presence of lizards in this land use, at least during the warm season (when sampling was performed). The two crops were characterised by comparable arthropod fauna composition and biomass, while the unmanaged cereal fields (where less lizards occurred) hosted higher levels of arthropod biodiversity than vineyards. Considering that *P. siculus* feeds mainly on epigeal arthropods without remarkable specialisations (Pérez-Mellado & Corti, 1993; Rugiero, 1994; Burke & Mercuro, 2002), these observations suggest that food availability, at least as revealed by our analyses, was not the key feature explaining the striking differences in the presence of lizards found between the two types of cultivated lands. Farming disturbance, as well, was not probably among the main factors influencing lizard abundance and distribution. In fact, cereal fields were not managed during the study, while vineyards underwent the ordinary management, including machinery activity.

In accordance with Díaz & Carrascal (1991), who suggested that the structural requirements of habitats play a primary role in shaping lizard abundance, much greater than the role played by food availability, the very dissimilar habitat structure of cereal fields and vineyards could be a key factor influencing lizard presence in our study system. At small scales, the occurrence of lizards, as well as of different animal groups, in terms of species composition and relative abundance, strictly depends on the vegetation features and physical structure of habitats (Tews et al., 2004; Vitt et al., 2007; Mizsei et al., 2020). Sowed lands are extremely simplified habitats, characterised by only herbaceous vegetation (e.g., the cereal ears), bare soil and, consequently, by the almost complete lack of shade and shelters, except for quite deep vertical crevices when the soil dries, which may provide temporary refuges from predators. Vineyards, on the contrary, display a more complex structure, offering lizards different shelters (soil crevices, holes at the base of the vine trunks and support poles, vine leaves and trunks) and shadow, when vines sprout (from the end of March). Such conditions in vineyards probably meet the conflicting needs imposed by thermoregulatory and anti-predatory requirements, allowing lizards to minimise the shuttling distance between sun (where they can bask) and the vegetation cover that provides both shade and the possibility of hiding (Carrascal & Díaz, 1989). Habitats that are more complex usually reduce the exposure to predation for lizards (Huey & Slatkin, 1976), among agricultural land uses as well (Biaggini et al., 2009). Analogously, the high density of lizards next to the margins of both land uses could be due to the complex structure of uncultivated boundaries in the study area, including shrubs and bushes, which are primarily important refuges for lizards (Strijbosch, 1988; Martín & López 1990; Martín & López 1998). Among cultivated lands, which are typically open habitats, the complexity of habitat structure allows higher abundance of reptiles in terms of both individuals and species (Biaggini & Corti, 2015). This pattern fits also if focussing on *P. siculus*, whose abundance inside agricultural lands follows a gradient of habitat complexity, higher in olive groves followed by vineyards and arable lands (Table 1).

Although further studies are needed to better understand the activity patterns of lizards within crops, our observations give some basic information on the distribution and abundance of these vertebrates in agricultural lands, which may have useful implications for conservation. From the pattern of presence of a species inside a crop, we can infer its exposure to different threats such as habitat loss or management activities (e.g., chemical spread). In vineyards, *P. siculus* can probably find environmental conditions favourable enough to settle there, partly compensating for the habitat loss due to vineyard planting through adaptation to the new environment. However, the stable presence of lizards in vineyards may entail a high and direct exposure to the risks related to management activities, including mechanical practices (e.g., mechanical grape harvesting and tillage) and chemical application. There are few studies exploring the possible impacts of management on lizard's populations, mostly focussing on pesticide application (e. g., Amaral et al., 2012a; Amaral et al., 2012b) and, at our knowledge, none of them deals with long-term effects. Moreover, in wild populations, complex interactions among ecological factors and human induced alterations occur, making it difficult to understand the mechanisms that, in some cultivated lands, allow lizards to cope with agricultural managing. Focussing on such mechanisms could be key in order to assess the treatment thresholds allowing lizard populations to persist in land uses such as vineyards. In contrast, following our observations, lizards do not settle in cereal fields but exploit only the marginal zones of these crops (a few meters besides the uncultivated margins), probably for feeding or basking, as observed for other reptiles (Wisler et al., 2008). Thus, the presence of sowable lands, as extremely simplified habitats, results primarily in a definitive loss of habitat for lizards. Given the low dispersal ability of these vertebrates, the maintenance of uncultivated habitats becomes key for the conservation of lizards in agricultural areas dominated by arable lands. These observations further stress the negative impact that the expansion of huge monocultures has on the abundance and diversity of herpetofauna, along with the loss of those semi-natural landscape elements essential to maintain the connectivity in the unsuitable matrix of cultivated lands (Kleijn et al., 2011; Biaggini & Corti, 2015; Nopper et al., 2017). On the other hand, the field-scale analysis of lizard occurrence, suggests that in cereal fields the exposure to threats driven by management, such as chemical spread, is reasonably less direct than in vineyards. Consequently, the research effort to assess the risk for lizards to be exposed to pesticides in croplands should probably involve buffer habitats such as field margins, uncultivated patches, vegetated banks of rivers and ditches.

ACKNOWLEDGMENTS

We would like to thank S. Allain and S. Batista for their useful comments and suggestions; S. Perrone and F. Balò, "Azienda Agricola di Montepaldi" (University of Florence) for facilitating surveys in the study area.

REFERENCES

Amaral, M.J., Carretero, M.A., Bicho R.C., Soares, A.M.V.M & Mann, R.M. (2012a). The use of a lacertid lizard as a model for reptile ecotoxicology studies: Part 1 – Field demographics and morphology. *Chemosphere* 87, 757-764.

Amaral, M.J., Bicho R.C., Carretero, M.A., Sanchez-Hernandez, J.C., Faustino, A.M.R., Soares, A.M.V.M & Mann, R.M. (2012b). The use of a lacertid lizard as a model for reptile ecotoxicology studies: Part 2 – Biomarkers of exposure and toxicity among pesticide exposed lizards. *Chemosphere* 87, 765-774.

Avery, R.A. (1993). Diel variation in area of movement of the lizard *Podarcis siculus*. *Ethology Ecology & Evolution* 5, 511–518.

Benton, T.G., Vickery, J.A. & Wilson, J.D. (2003). Farmland biodiversity: is habitat heterogeneity the key? *Trends in Ecology & Evolution* 18, 182–8, doi: 10.1016/S0169-5347(03)00011-9.

Berry, O., Tocher, M.D., Gleeson, D.M. & Sarres, S.D. (2005). Effect of vegetation matrix on animal dispersal: genetic evidence from a study of endangered skinks. *Conservation Biology* 19, 855–864, doi: 10.1111/j.1523-1739.2005.00161.x.

Biaggini, M., Consorti, R., Dapporto, L., Dellacasa, M., Paggetti, E. & Corti, C. (2007). The taxonomic level order as a possible tool for rapid assessment of Arthropod diversity in agricultural landscapes. *Agriculture Ecosystems & Environment* 122, 183–191, doi: 10.1016/j.agee.2006.12.032.

Biaggini, M., Berti, R. & Corti, C. (2009). Different habitat, different pressures? Analysis of the escape behaviour and ectoparasite load in *Podarcis sicula* (Lacertidae) populations in different agricultural habitats. *Amphibia-Reptilia* 30, 453–461, doi: 10.1163/156853809789647068

Biaggini, M. & Corti, C. (2015). Reptile assemblages across agricultural landscapes: where does biodiversity hide? *Animal Biodiversity and Conservation* 38.2, 163–174.

Biaggini, M. & Corti, C. (2017). Variability of breeding resource partitioning in a lacertid lizard at field scale. *Animal Biology* 67, 81–92, doi: DOI: 10.1163/15707563-00002523.

Biaggini, M., Lo Cascio, P., Bassu, L., Bazzoffi, P., Barbagli, F., Nulchis, V. & Corti, C. (2015a). Ecological focus area – EFA: the biological value of olive groves. A case study in Sardinia (Italy) / Ecological focus area - EFA: il valore biologico degli oliveti. Un caso di studio in Sardegna. *Italian Journal of Agronomy* 10(s1), 748, doi: 10.4081/ija.2015.748.

Biaggini, M., Lo Cascio, P., Bazzoffi, P. & Corti, C. (2015b). Effectiveness of GAEC cross-compliance Standard 4.2c for biodiversity conservation in set-asides, part II (ground-dwelling Arthropods and Vertebrates) / Efficacia dello Standard BCAA di Condizionalità 4.2c per il mantenimento della biodiversità nei suoli ritirati dalla produzione, parte II (Artropodi epigei e Vertebrati). *Italian Journal of Agronomy* 10(s1), 699, doi: 10.4081/ija.2015.699.

Böhm, M., Collen, B., Baillie, J.E.M., Bowles, P., Chanson, J., Cox, N., Hammerson, G., Hoffmann, M., Livingstone, S.R., Ram, M., Rhodin, A.G.J., Stuart, S.N. et al. (2013). The Conservation Status of the World's Reptiles. *Biological Conservation* 157, 372-385, doi: 10.1016/j.biocon.2012.07.015.

Braña, F. (2003). Morphological correlates of burst speed and field movement patterns: the behavioural adjustment of locomotion in wall lizards (*Podarcis muralis*). *Biological Journal of the Linnean Society* 80, 135–146, doi: 10.1046/j.1095-8312.2003.00226.x.

Burke, R.L. & Mercuro, R.J. (2002). Food habits of a New York population of Italian Wall Lizard, *Podarcis siculus* (Reptilia, Lacertidae). *American Midland Naturalist* 147, 368–375, doi: 10.1674/0003-0031(2002)147[0368:FHOANY]2.0.CO;2.

Capula, M., Luiselli, L. & Rugiero, L. (1993). Comparative ecology in sympatric *Podarcis muralis* and *P. sicula* (Reptilia: Lacertidae) from the historical centre of Rome: what about competition and niche segregation in an urban habitat? *Italian Journal of Zoology* 60, 287–291, doi: 10.1080/11250009309355825.

Carrascal, L.M. & Díaz, J.A. (1989). Thermal ecology and spatio-temporal distribution of the Mediterranean lizard *Psamniodronius algirus*. *Holarctic Eco1ogy* 12, 137–143, doi: 10.1111/j.1600-0587.1989.tb00832.x.

Corti, C., Biaggini, M. & Capula, M. (2010). *Podarcis siculus* (Rafinesque-Schmaltz, 1810). In *Fauna d'Italia. Reptilia*, 407–417. Corti, C., Capula, M., Luiselli, L. & Sindaco, R. (eds). Bologna: Edizioni Calderini de Il Sole 24 Ore, Editoria Specializzata S.r.l.

Corti, C., Barbagli, F., Bassu, L., Di Cerbo, A.R., Lo Cascio, P., Sillero, N., Nulchis, V., Ceccolini, F., Paggetti, E., Romano, A., Bazzoffi, P. & Biaggini, M. (2015). Monitoraggio della biodiversità in relazione all'applicazione degli standard di condizionalità: 4.2c, 4.6, 4.3 (olivo). Technical Report. *Italian Journal of Agronomy* 10(s1), doi: 10.4081/ija.2015.749.

Díaz, J.A. & Carrascal, L.M. (1991). Regional distribution of a Mediterranean lizard: influence of habitat cues and prey abundance. *Journal of Biogeography* 18, 291–297.

Díaz, J.A., Monasterio, C. & Salvador, A. (2006). Abundance, microhabitat selection and conservation of eyed lizards (Lacerta lepida): a radiotelemetric study. *Journal of Zoology* 268, 295–301, doi: 10.2307/2845399.

Diego-Rasilla, F.J. (2003). Influence of predation pressure on the escape behavior of *Podarcis muralis* lizards. *Behavioural Processes* 63, 1–7, doi: 10.1016/S0376-6357(03)00026-3.

Driscoll, D.A. (2004). Extinction and outbreaks accompany fragmentation of a reptile community. *Ecological Applications* 14, 220–240, doi: 10.1890/02-5248.

Foà, A., Bearzi, M. & Baldaccini, N.E. (1990). A preliminary report on the size of the home range and on the orientational capabilities in the lacertid lizard *Podarcis sicula*. Thirteen Meeting of the Italian Society for the Study of Animal Behaviour, Perugia, Italy, May 25-27, 1989. *Ethology Ecology & Evolution* 3(2), 310, doi: 10.1080/08927014.1990.9525443.

Foà, A., Tosini, G. & Avery, R. (1992). Seasonal and diel cycles of activity in the ruin lizard, *Podarcis sicula*. *Herpetological Journal* 2, 86–89.

Gibbons, J.W., Scott, D.E., Ryan, T.J., Buhlmann, K.A., Tuberville, T.D., Metts, B.S., Greene, J.L., Mills, T., Leiden, Y., Poppy, S. & Winne, C.T. (2000). The Global Decline of Reptiles, Déjà Vu Amphibians. *BioScience* 50(8), 653–666, doi: 10.1641/0006-3568(2000)050[0653:TGDORD]2.0.CO;2.

Huey, R.B. (1982). Temperature, physiology, and the ecology of reptiles. In, Gans, C. & Pough, F.H. (Eds). *Biology of the Reptilia*, vol. 12, pp. 25–91. Academic Press, London.

Huey, R.B. & Slatkin, M. (1976). Costs and benefits of lizard thermoregulation. *The Quarterly Review of Biology* 5, 363–384, doi: 10.1086/409470.

Kleijn, D., Rundlöf, M., Scheper, J., Smith, H.G. & Tscharntke, T. (2011). Does conservation on farmland contribute to halting the biodiversity decline. *Trends in Ecology and Evolution* 28, 474–481.

Martín, J. & López, P. (1990). Amphibians and reptiles as prey of birds in southwestern Europe. *Smithsonian Herpetological Information Service* 82, 1–43.

Martín, J. & López, P. (1996). Avian predation on a large lizard (*Lacerta lepida*) found at a low population densities in Mediterranean habitats: an analysis of bird diets. *Copeia* 1996, 722–726.

Martín, J. & López, P. (1998). Shifts in microhabitat use by the lizard *Psammodromus algirus*: responses to seasonal changes in vegetation structure. *Copeia* 1998, 780–786, doi:10.2307/1447815.

Mizsei, E., Fejes, Z., Malatinszky, Á., Lengyel, S. & Vadász, C. (2020). Reptile responses to vegetation structure in a grassland restored for an endangered snake. *Community Ecology* 21, 203–212, doi: 10.1007/s42974-020-00019-2.

Nopper, J., Lauströer, B., Rödel, M.O. & Ganzhorn, J.U. (2017). A structurally enriched agricultural landscape maintains high reptile diversity in sub-arid south-western Madagascar. *Journal of Applied Ecology* 54, 480–488, doi: 10.1111/1365-2664.12752.

Ockleford, C., Adriaanse, P., Berny, P., Brock, T., Duquesne, S., Grilli, S., Hernandez J.A., Bennekou, S., Klein, M., Kuhl, T., Laskowski, R., Machera, K., Pelkonen, O., Pieper, S., Stemmer, M., Sundh, I., Teodorović, I., Tiktak, A., Topping, C. & Smith, R. (2018). Scientific Opinion on the state of the science on pesticide risk assessment for amphibians and reptiles. *EFSA Journal* 16(2), doi: 10.2903/j.efsa.2018.5125.

Pérez-Mellado, V. & Corti, C. (1993). Dietary adaptation and herbivory in lacertid lizards of the genus *Podarcis* from western Mediterranean islands. (Reptilia: Sauria). *Bonner Zoologische Beiträge* 44, 193–220.

Regal, P.J. (1983). The adaptive zone and behaviour of lizards. In, Huey, R.B., Pianka, E.R., Schoener, T.W. (Eds). *Lizard Ecology: Studies of a Model Organism*, pp. 105–118.

Harvard University Press, Cambridge, MA, doi: 10.4159/harvard.9780674183384.

Rugiero, L. (1994). Food habits of the ruin lizard, *Podarcis sicula* (Rafinesque-Schmaltz, 1810) from a coastal dune in central Italy (Squamata: Sauria: Lacertidae). *Herpetozoa* 7, 71–73, doi: 10.1111/j.1469-7998.1966.tb03886.x.

Rugiero, L. (1997). Tail loss and escape behaviour in the Common Wall Lizard *Podarcis muralis* Laurenti, 1768. A preliminary analysis (Squamata: Sauria: Lacertidae). *Herpetozoa* 10 (3/4), 149–152.

Sala, O.E., Chapin III, F.S., Armesto, J.J., Berlow, E., Bloomfield, J. Dirzo, R., Huber-Sanwald, E., Huenneke, L.F., Jackson, R.B., Kinzig, A., Leemans, R., Lodge, D.M., Mooney, H.A. & Wall, D.H. (2000). Global biodiversity scenarios for the year 2100: *Science* 287(5459), 1770–1774, doi: 10.1126/science.287.5459.1770.

StatSoft, Inc. (2011). STATISTICA (data analysis software system), version 10. www.statsoft.com.

Strijbosch, H., 1988. Habitat selection of *Lacerta vivipara* in a lowland environrnent. *Herpetological Journal* 1, 207–210.

Tews, J., Brose, U., Grimm, V., Tielbörger, K., Wichmann, M. C., Schwager, M. & Jeltsch, F. (2004). Animal species diversity driven by habitat heterogeneity/diversity: the importance of keystone structures. *Journal of Biogeography* 31, 79–92.

Todd, B.D., Willson, J.D. & Gibbons, J.W. (2010). The global status of reptiles and causes of their decline. In *Ecotoxicology of Amphibians and Reptiles*, Second Edition, 47–67. Sparling, D.W., Bishop, C.A. & Krest, S. (eds). Pensacoda, FL, USA: CRC Press.

Tscharntke, T., Klein, A.M., Kruess, A., Steffan-Dewenter I. & Thies, C. (2005). Landscape perspectives on agricultural intensification and biodiversity - ecosystem service management. *Ecology Letters* 8, 857–74, doi: 10.1111/j.1461-0248.2005.00782.x.

Van Damme, R., Bauwens, D., Castilla, A.M. & Verheyen, R. (1990). Comparative thermal ecology of the sympatric lizards *Podarcis tiliguerta* and *Podarcis sicula*. *Acta Oecologica* 11, 503–512.

Vitt, L.J., Colli, G.R., Caldwell, J.P., Mesquita, D.O., Garda, A.A. & França, F.G.R. (2007). Detecting variation in microhabitat use in low-diversity lizard assemblages across small-scale habitat gradients. *Journal of Herpetology* 41(4), 654–663, doi: 10.1670/06-279.1.

Wisler C., U., Hofer & Arlettaz, R.L. (2008). Snakes and Monocultures: Habitat selection and movements of female Grass Snakes (*Natrix natrix* L.) in an agricultural landscape. *Journal of Herpetology* 42(2), 337–346, doi: 10.1670/07-027.1.

Accepted: 18 December 2020