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Crop diversity and rotation may increase dispersal opportunities of reptiles in a heterogeneous agroecosystem

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ABSTRACT

Land sharing strategies in agricultural landscapes need to allow for organisms to move between natural areas and different crops within an agro-ecological landscape in order to reduce extinction probability and the negative effects of small isolated populations. In this study, we tested whether legume or wheat fields differed in their effects on reptiles' movement patterns. We conducted our study in an agro-ecosystem consisting of small isolated natural habitat patches nested within agricultural fields. We trapped reptiles in sampling arrays before and after harvest in both wheat and legume fields, and in adjacent natural habitat patches. For both crops, prior to harvest, we found an increase in movements of *Trachylepis vittata*, the most common reptile in our study, from the natural habitat patches into fields, but negligible movement in the opposite direction. In both crops before harvest, the individuals that moved into the fields were adults of better body condition than those remaining in the natural habitat patch, suggesting that long-distance movements were only possible for individuals with high prospective fitness. After harvest, no movements were documented between wheat fields and natural habitat patches. However, in legume fields, a high symmetrical movement (i.e. in both directions) of individuals of similar body condition between fields and natural habitat patches took place. Importantly, newborn lizards were only found in the natural habitat patches and in post-harvest legume fields. Our results suggest that agricultural heterogeneity, through a mixture of crop types may mitigate some of the negative effects of particular crops on biodiversity. As crop rotation between wheat and legume fields is common worldwide, our findings highlight the importance of creating an agricultural mosaic to enhance biodiversity permeability within the agricultural matrix.

1. Introduction

The current need to increase food supply is being tackled by an expansion of farming area and an intensification of agricultural practices, both of which cause biodiversity loss (Bommarco et al., 2013; Green et al., 2005). Consequently, methods which ensure food production while maximizing biodiversity conservation within the agricultural systems ('Wildlife Friendly Agriculture'; WFA) have become one of the major challenges for modern agriculture (Matson et al., 1997; Mendenhall et al., 2014; Tscharntke et al., 2012a,b; West et al., 2014). A key approach of WFA is 'land sharing' (Fischer et al., 2011, 2008; Phalan et al., 2011) which strives to promote a balance between food production and conservation by leaving natural habitat patches within the agricultural matrix (Benton et al., 2003; Duelli and Obrist, 2003; Fahrig et al., 2011; Green et al., 2005; Troupin and Carmel, 2014; Tscharntke et al., 2012a,b; West et al., 2014).

However, keeping fragmented natural patches within an agricultural landscape is only effective if those patches can support ecological processes for long-term persistence of populations (Tscharntke et al., 2012b). One of these ecological processes that are vital for the long-term survival of populations are dispersal of organisms between the fragmented natural habitat patches. Fully isolated patches, especially small ones, which are common within many agricultural landscapes, may result in reduced population sizes and lower species diversity, due to stochastic effects as well as amplified antagonistic interactions. Hence, the ability of native species to move between patches throughout the agricultural matrix is a crucial requirement for any WFA implementation.

Agricultural heterogeneity can provide diverse opportunities for native species to survive within the agricultural matrix (Blitzer et al., 2012; Tscharntke et al., 2012b). These opportunities result from different crop dynamics (e.g., time of seeding and crop

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development), crop structure (e.g., plant formation and architecture) and agricultural practices (e.g., chemicals' distribution and machinery use). Consequently, it is essential to explore how different crop dynamics affect movement patterns within a given agricultural landscape.

We study agroecological issues in the Southern Judea Lowlands (SJL; Fig. 1a) (Giladi et al., 2014, 2011; May et al., 2013a,b; Rotem et al., 2016, 2013; Yaacobi et al., 2007a,b). Thousands of years of human inhabitance and recent intensive agricultural use has formed a landscape consisting of natural habitat patches at different degrees of isolation, surrounded by agricultural fields. The natural habitat patches' main vegetation types are characterized by semi-steppe batha (Mediterranean scrubland) and grassland (Giladi et al., 2011). Overall, 342 plant species have been identified in this area, belonging to three phytogeographic zones – Mediterranean, Irano-Turanian and Saharo-Arabian (Giladi et al., 2011, 2014; May et al., 2013a,b). The most dominant perennial species are the dwarf shrub *Sarcopoterium spinosum* in the batha vegetation and the tussock grasses *Hyparrhenia hirta* and *Hordeum bulbosum* in the grassland. The most common annual species are *Avena sterilis*, *Anagallis arvensis*, *Linum strictum*, *Urospermum picriodes*, and *Plantago afra* (Giladi et al., 2011).

The natural habitat patches in this landscape host a high diversity of reptiles. In previous censuses, this landscape has been shown to host 20 reptile species (approximately 20% of all known reptile species in Israel) (Rotem et al., 2016, 2013).

The agricultural fields within this landscape are usually planted with either wheat or legumes (mainly pea or clover). While the planting of both crops takes place in November, legumes and wheat differ in harvest time – legumes in April and wheat in June. In wheat fields, after harvest, the hay is collected immediately into stacks and removed from the field. As a result, the wheat field turns into an exposed and poor habitat for many organisms, especially vertebrates. In contrast, after legume harvest, the pulled plants are piled in long lines, usually stretching from one natural habitat patch to another. These piles of greenery remain in the field to dry in the sun for several weeks until removal.

This paper aims to analyze the movement patterns of reptiles between natural habitat patches and the surrounding wheat and legume fields in order to investigate whether these crops provide different dispersal opportunities. In wheat fields, using the model species *Trachylepis vittata* [Scincidae], we (Rotem et al., 2013) have already shown that individuals asymmetrically move from natural habitat patches to the fields during the crop's growing season, creating a dense population within the wheat fields. However, harvest activities cause a sharp decline in population size in the wheat fields (acting as an ecological trap; Rotem et al., 2013). Thereafter, no movement between the natural habitat patches and the wheat fields takes place resulting in complete functional isolation of the natural habitat patches surrounded by wheat fields. Here we ask whether legume cropping allows for different movement opportunities for reptiles trapped in natural habitat patches, and whether agricultural spatial heterogeneity enhances dispersal within the landscape. Given that wheat and legume are grown in rotation worldwide, identifying differences in animal dispersal ability between legume and wheat can inform WFA approaches to agricultural spatial crop planning.

Our current study intends to emphasize three main points: First, because the agricultural practice in legume fields differs from that of wheat fields, and hence providing different opportunities for wildlife, it is important to review agricultural protocols when dealing with wildlife-friendly agriculture. Second, because different crops differ between each other in affecting native populations, agricultural heterogeneity at large scales may enhance

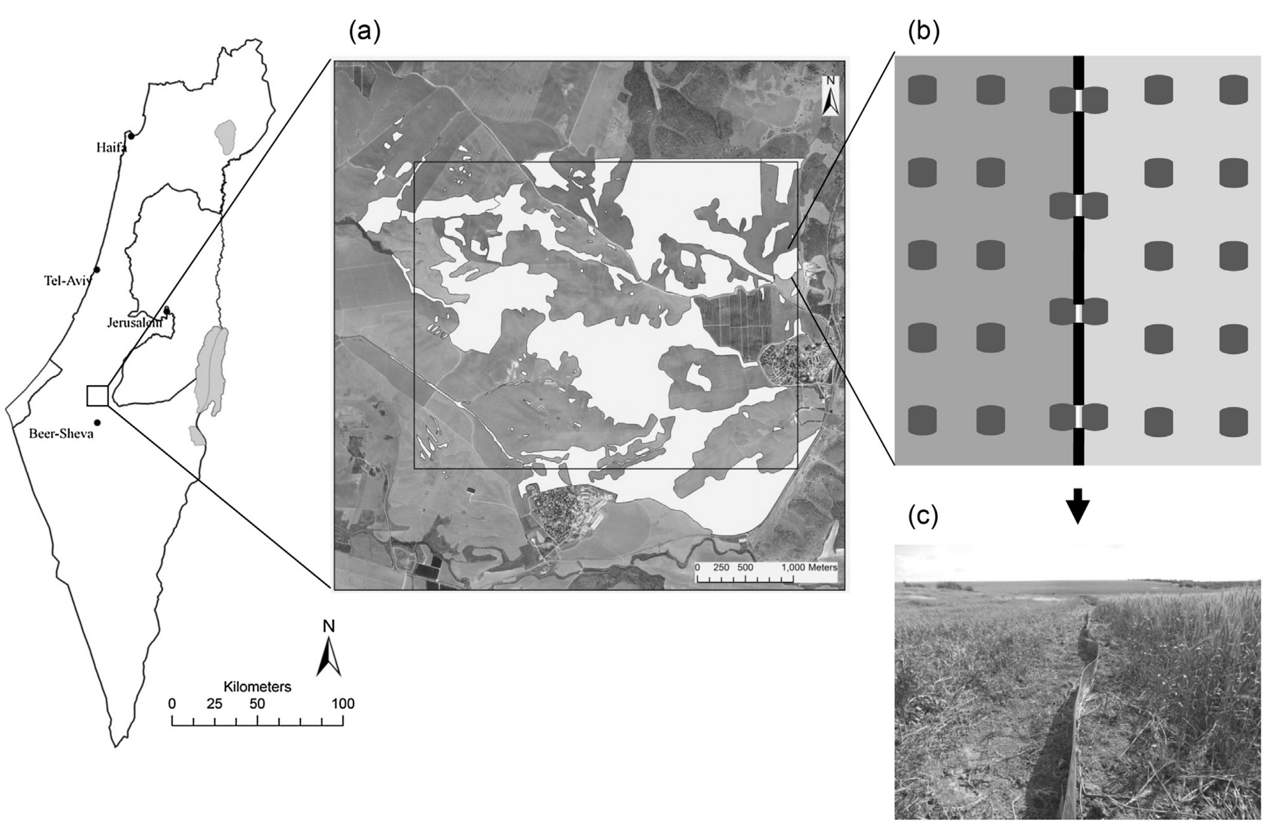

Fig. 1. Map of the research area and the study site (a), where white polygons represent natural patches surrounded by agricultural fields. A diagram of a trapping array (b) shows the fence (black line) and the trapping array in each habitat and along the separating fence. A picture of the patch-field edge and the separating fence is given in (c).