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Short communication

Wheat fields as an ecological trap for reptiles in a semiarid agroecosystem

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ABSTRACT

Intensive agricultural activity over large areas on earth, which is necessary to meet the increasing demand of a growing human population, may lead to biodiversity loss. This loss may be mitigated by keeping natural and semi-natural patches within agricultural fields to allow the maintenance of biological diversity ('Wildlife Friendly Agriculture'). We conducted our study in an agroecosystem comprised of small isolated patches nested within agricultural fields. We trapped reptiles in 13 sampling sites, each of which included arrays of pitfall traps in a natural patch, in the adjacent wheat field and at the patch-field edge. We conducted six trapping sessions in the spring – four times before, once immediately after and once a week after the wheat harvest. Prior to the harvest, we found an intensive movement of *Trachylepis vittata*, the most common reptile in our study, from the semi-natural patches into the fields, but negligible movement in the opposite direction. This pre-harvest directional movement corresponded with higher abundance of prey (i.e., arthropods) in the wheat field compared to the natural patches in early spring. The individuals that moved into the fields were adults of better body condition than those remaining in the patch, suggesting that the motivation for movement was habitat preference by individuals with high prospective fitness rather than the exclusion of subordinates. The population of *T. vittata* in the wheat fields and movement across habitats dropped to zero during and after the harvest. Our results provide strong evidence that the agricultural fields serve as an ecological trap to organisms inhabiting nearby natural habitats. We suggest that plans for Wildlife-Friendly Agriculture for biodiversity conservation should consider also potential negative effects, such as the ecological trap effect.

1. Introduction

A rapidly growing global human population coupled with an increase in per-capita consumption challenge modern agriculture to increase productivity in order to meet the increasing demand. This challenge is being tackled by both an expansion of farming area and an intensification of agricultural practices. The vast terrestrial areas affected by agriculture (about 80% globally; MEA, 2005), agricultural intensification, and the cultivation of monocultures are all expected to cause biodiversity loss (FAO, 2007; Green et al., 2005). One recent approach to alleviate the negative effects of agriculture on biodiversity is 'Wildlife Friendly Agriculture', which apparently promotes a balance between food production and conservation by, among others, leaving natural habitat patches within a heterogeneous agricultural landscape (Green et al., 2005). Accordingly, preservation of natural or semi-natural patches within the agricultural matrix is considered an effective and relatively cheap way to preserve biodiversity (Aarssen and Schamp, 2002; Benton et al., 2003; Duelli and Obrist, 2003). In addition to biodiversity conservation, this approach may be beneficial also for farmers because of the positive ecosystem services that natural habitats provide for agriculture (Rosenzweig, 2003a,b; Tscharntke et al., 2005; Bommarco et al., 2013).

However, the proximity of natural habitat patches to agricultural matrix may also affect animal behavior, in general, and habitat selection, in particular (Tscharntke et al., 2012). The selection of habitats in which to shelter, feed and reproduce can dramatically impact organism fitness. Consequently, most animals have evolved abilities to sense reliable cues regarding habitat quality and to move to a better habitat whenever possible (Abramsky et al., 1985; Pulliam, 1988).

However, the ability to reliably assess habitat quality is often compromised in human-made environments (Kristan, 2003; Battin, 2004). Cultivation-related fluctuation in habitat quality

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may attract individuals at certain times and be detrimental at other times (Best, 1986; Bollinger et al., 1990). The case where an organism prefers low-quality habitats over other available better habitats is called an 'ecological trap' (Dwernych and Boag, 1972; Donovan and Thompson, 2001; Hawlena et al., 2010), which might be considered a special case of source-sink dynamics (Pulliam, 1988; Battin, 2004). Such ecological traps may have far-reaching consequences for the populations in both the low and the high quality habitats. Robertson and Hutto, (2006) offer three criteria that define an 'ecological trap': "*(1) individuals should have exhibited a preference for one habitat over another*; *(2) a reasonable surrogate measure of individual fitness should have differed among habitats; and (3) the fitness outcome for individuals settling in the preferred habitat must have been lower than the fitness attained in other available habitat"*.

Our study area, the Beit-Nir agroecosystem, is located at the northern part of Southern Judea Lowlands (SJL), central Israel (31°30′52″N 34°52′36″E), approximately 50 km southwest of Jerusalem (Fig. 1a). Thousands of years of human inhabitance (Ben-Yosef, 1980) and recent intensive agricultural practice formed a landscape consisting of natural habitat patches at different degrees of isolation, surrounded by agricultural fields (mainly wheat) vineyards and olive groves. The presence of semi-natural patches within this agricultural landscape can potentially host a high diversity of reptiles. However, these patches are positioned within wheat fields, a habitat with potentially highly fluctuating quality due to seasonal cultivation.

Using reptiles, we examine the main hypothesis that the agricultural system serves as an ecological trap, as defined by Robertson and Hutto (2006), where many individuals move to and permanently occupy the agricultural fields, eliminated by the agricultural machinery before or during the reproduction season. We contrast this hypothesis with an alternative one, stating that the agricultural system is used for a daily foraging ground by individuals that mainly occupy the adjacent natural habitats.

Our model species *Trachylepis vittata* [Scincidae] is common along the eastern Mediterranean basin and in North Africa (Van der Winden et al., 1995). It is frequently found under stones in the early morning until the ambient temperature rises above 14 °C. This species also uses rocks as shelters to escape rain and other extreme weather (Clark and Clark, 1973). It measures 225 mm from snout to tail and feeds on arthropods (Schleich et al., 1996). Females give birth to live offspring between July and August (Disi et al., 2001, p. 226).

2. Methods

2.1. Study design and survey protocol

We surveyed reptiles in 13 sampling sites, each including a natural patch, an adjacent wheat field and the patch-field edge (Fig. 1b). At each site we installed 40 traps, positioned in two arrays, each comprised of 20 one-liter dry pitfall traps. The traps were arranged in two parallel lines at distances of 10 m and ~15 m on either side of the patch-field edge (Fig. 1b). Additionally, on the patch-field edge we used a polypropylene multiwall sheet to build a 100 m-long and 40 cm-high fence (Fig. 1b) that directs all reptiles' movement between the natural patch and the agricultural field to passageways located every 20 m along the fence (Fisher et al., 2008). At those passageways we placed two one-liter dry pitfall traps, one at each side (total of 10 one-liter dry pitfall traps along each fence). These sampling methods enabled us to simultaneously asses the community structure and monitor the physical condition of reptiles in the natural patch, in the field, while crossing from the natural patch to field and while crossing in the opposite direction (Jenkins and McGarigal, 2003).

We trapped reptiles during six sessions throughout the spring (March to June) – four times before the wheat harvest, immediately after the harvest and one week later. In each session, traps were left open for 72 h. Trapped animals were measured (i.e. weight, snout-to-vent-length, tail length) and identified to species (and sex when possible; see results). Individuals' physical condition was assessed by an index of body condition (IC; Andrews and Wright, 1994). Initially we intended on using individual marking to follow the reptiles' movement. However, as marking of individuals during the four first sampling sessions resulted in no recapture at all, this method was not used further on. We released all captured individuals back to the habitat where they were captured (in the natural patch or agricultural field) or to the habitat they were aiming for (in the patch-field edge). We averaged all the observations from each combination of 'habitat' × 'session' × 'site' prior to any statistical analysis and used these summarized data as our replicates, thus avoiding any pseudo-replication.

Incidentally, the pitfall traps also collected arthropods that were later identified in the lab to their order level. Previous studies have found a positive correlation between insect abundance and reptile abundance (Rocha et al., 2008). As all the studied reptile species were predators, having insects as a dominant component of their diet, we assumed that arthropod abundance could serve as a good indicator for habitat quality.

3. Results

Throughout the study, we trapped 352 reptiles, belonging to 9 species. Most of the trapped individuals (271) belonged to our model species, *T. vittata*. The vast majority (244) of the 271 individuals of *T. vittata*, throughout the season and in all habitat types were adults, 16 were sub-adults (mainly in the pre-harvest sessions only, and in all habitat types) and only 11 were juveniles, all of which were captured in the natural patch habitat in the post-harvest session. Although it was sometimes possible to determine the sex of trapped individuals, in most cases it could not be reliably done. Therefore, our analysis was not stratified by sex or by age.

We found a significant effect of both sampling time and habitat (repeated-measures ANOVA, $F_{(5,\ 240)} = 10.43$, $p < 0.001$, and $F_{(3,\ 48)} = 72.46$, $p < 0.001$, respectively) as well as their interaction ($F_{(15,\ 240)} = 9.0643$, $p < 0.0001$) on *T. vittata*'s abundance (Fig. 2).

T. vittata abundance (Fig. 2) in natural patches remained relatively constant throughout the entire study period. In contrast, the number of *T. vittata* found in the wheat field varied. Early in the season only a few individuals occurred within the field habitat, but their number increased throughout the spring until the harvest. After the wheat harvest, not a single individual was found within the field habitat. The reptiles' movement across habitats was unidirectional with an intensive movement from the natural patches into the wheat fields in early spring (38 individuals observed). Only two individuals attempted crossing in the opposite direction throughout the entire season. The very low densities of other reptile species precluded us from conducting meaningful analyses at the species level. Nevertheless, the general patterns for all the rest of the reptile community combined was similar to the results found for *T. vittata*. The number of reptiles (excluding *T. vittata*) captured per trapping array per session remained constant in the natural patch habitat throughout the season (0.69 and 0.77 for pre-harvest and post-harvest, respectively). It dropped sharply in the field habitat (from 0.25 individuals in the pre-harvest to 0 in the post-harvest). Prior to the harvest, twice as many individuals crossed from the patch to the field than in the opposite