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Can agri-environmental schemes enhance non-target species? Effects of sown wildflower fields on the common hamster (*Cricetus cricetus*) at local and landscape scales

Christina Fischer [a,*], Christian Wagner [b]

[a] Restoration Ecology, Department of Ecology and Ecosystem Management, Technische Universität München, Emil-Ramann-Str. 6, 85354 Freising, Germany
[b] Bavarian State Research Centre for Agriculture, Institute for Organic Farming, Soil and Resource Management, 85354 Freising, Germany

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ABSTRACT

During the last decades, agriculture has been rapidly intensified, resulting in a strong decline in species diversity. Therefore the common agricultural policy (CAP) of the EU implemented agri-environmental schemes (AES) for an environmentally-friendly management of agricultural areas. Sown wildflower fields are one of these measures aimed at enhancing insect diversity and related ecosystem services. However, little is known about the impacts of AES on rare and non-target species. To study the effect of these AES on a non-target species, the occurrence of the endangered common hamster (*Cricetus cricetus*) was mapped by counting reopened winter burrows on paired sown wildflower fields and agricultural fields in North-West Bavaria, Germany. Concentration effects in sown wildflower fields and the distribution of *C. cricetus* in adjacent agricultural fields were studied by mapping burrows up to a distance of 200 m from sown wildflower and agricultural fields. Furthermore, *C. cricetus* occurrence in relation to local (vegetation density, cover of grasses, vegetation height, size of wildflower fields) and landscape scale parameters (percentage of arable land, grassland, fallow land, distance to the nearest forest, and settlement) of sown wildflower fields was analysed. Results show that there was a concentration of *C. cricetus* in sown wildflower fields, while densities in adjacent agricultural fields were constantly low. Hamster occurrence was negatively related to vegetation density and grass cover on sown wildflower fields and positively related to distance to the nearest forests, percentage of arable land and fallow land around wildflower fields. In conclusion, we could show that sown wildflower fields can be an ideal habitat for non-target species, such as the common hamster. However, local and landscape scale parameters of sown wildflower fields need to be considered when designing AES.

1. Introduction

European landscapes are dominated by agriculture, which covers almost half of the total surface area and has created a variety of different habitats (Halada et al., 2011). It has been estimated that half of the species in Europe depend on these agriculturally used habitats (Stoate et al., 2009). However, during the last decades, agriculture has been rapidly intensified, due to increasing bioenergy production and global food demand (Tscharntke et al., 2012). Agricultural intensification is related to a loss of crop diversity, an increasing use of pesticides and synthetic fertilizers as well as intensified tillage leading to soil compaction and nutrient runoff on the local scale. On the landscape scale agricultural intensification is related to the fragmentation and destruction of semi-natural habitats which are replaced by larger field blocks resulting in a homogenization of the landscape (Fischer and Lindenmayer, 2007; Power, 2010). These land use changes led to a loss of farmland biodiversity all over Europe during the last decades (Stoate et al., 2001). Therefore, in the early 1980s the Common Agricultural Policy (CAP) of the EU pursued an environmentally friendly farming by providing compensations for loss of income to farmers (Henle et al., 2008). As an instrument for nature conservation and landscape protection agri-environmental schemes (AES) were developed and integrated into the CAP at different spatial scales (national, regional, local) to be adapted to different economic and environmental conditions (Henle et al., 2008; Uthes and Matzdorf, 2013). AES are often designed to enhance multiple species, and they can also have an impact on rare and non-target species of conservation concern (Batáry et al., 2015; Kleijn et al., 2011; Potts et al., 2006).

One of these AES is the creation of sown wildflower strips or fields aiming to enhance insect diversity and related ecosystem services, such as crop pollination and biological pest control, as well as increasing diversity of plants and farmland birds. A number of European countries, such as Austria, Finland, Germany, the UK, Switzerland and Sweden

* Corresponding author.
E-mail address: christina.fischer@tum.de (C. Fischer).

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included sown wildflower strips and fields in their AES programs (Haaland et al., 2011; Scheper et al., 2015). After establishment, sown wildflower strips and fields persist for several years (often 2–4 years) and management is either prohibited or restricted to be extensive depending on regional regulations (Haaland et al., 2011).

Positive effects of sown wildflower strips and fields compared to cropped areas have been shown for the diversity and abundance of insects (reviewed in Haaland et al., 2011), for the territory density of some breeding farmland birds (Zollinger et al., 2013), as well as for the abundance and species richness of small mammals (Arlettaz et al., 2010). Due to their permanent vegetation cover compared to agricultural fields, sown wildflower strips and fields can have a positive effect on farmland biodiversity at the landscape scale, enhancing floral resources for pollinators (Scheper et al., 2015), as well as seed and insect food resources for small mammals and birds (Tscharntke et al., 2011; Vickery et al., 2009). Thereby, the effects of AES strongly depend on the distribution of such resources on the landscape scale, with either a concentration of populations in habitat patches, if the landscape provides few resources or a distribution of individuals on many habitat patches of resource-rich landscapes due to spill-over effects, resulting in lower densities per habitat patch (Kleijn et al., 2011; Tscharntke et al., 2012). In contrast, local differences of sown wildflower strips and fields in vegetation structure and composition on species occurrence have been rarely studied (but see Kollmann and Bassin, 2001 for small mammals; Woodcock et al., 2005 for beetles; Zollinger et al., 2013 for birds).

The common hamster (*Cricetus cricetus*) occurs in agricultural landscapes on deep heavy soils such as loess and loess loam, where it can establish extensive burrows (Kryštufek et al., 2008). Just like other rodents, it can contribute to soil aeration and mineralization due to its burrowing activity (Laundré and Reynolds, 1993). As prey of many raptors, such as red kite (*Milvus milvus*), black kite (*M. migrans*), common buzzard (*Buteo buteo*) and lesser spotted eagle (*Aquila pomarina*), as well as terrestrial predators, such as red fox (*Vulpes vulpes*), stoat (*Mustela erminea*) and sporadically badger (*Meles meles*), *C. cricetus* can contribute to the stabilization of food webs in agricultural landscapes (Kayser et al., 2003). Because of its high reproduction rate *C. cricetus* has been a pest species in agricultural landscapes (Nechay et al., 1977; Weinhold, 2008). However, land use changes due to agricultural intensification (La Haye et al., 2014), predation pressure, climate change (reviewed in Monecke, 2013), as well as habitat fragmentation through human infrastructure (Hell et al., 2005) led to a dramatic decline in hamsters' population densities (Schreiber, 2010; Ulbrich and Kayser, 2004; Villemey et al., 2013; Weinhold, 2008). On a local scale, microsite characteristics, such as low vegetation cover in spring (March and April) can further increase hamsters' mortality up to 18% due to high predation rates (Kayser et al., 2003). Consequently hamsters in Western Europe often occur in highly fragmented populations (Banaszek et al., 2011) and were listed on Appendix II of the Bern Convention and Annex IV of the EU Habitats and Species Directive (Kryštufek et al., 2008). In Germany, the hamster is classified as endangered and therefore regional conservation measures, such as the "common hamster protection plan" were established paying subsidies to farmers for a "hamster-friendly" management of agricultural areas (Schreiber, 2010). However, these measures are locally restricted and very specific for the protection of *C. cricetus*. Hence, the question arises if more general AES, such as the establishment of sown wildflower strips and fields, are suitable for the conservation and related ecosystem functions of non-target species, such as the common hamster.

In the present study, we compared the number of reopened winter burrows in sown wildflower fields with cropped fields in agricultural areas in Lower Franconia, Bavaria, where one of the remaining isolated hamster populations in Germany occurs (Schreiber, 2010). Furthermore, the density and occurrence probability of *C. cricetus* in wildflower fields were investigated in relation to local (e.g. vegetation density, size of the sown wildflower field) and landscape scale effects (e.g. percentage of arable land in a radius of 500 m, distance to the nearest forest and settlement), to answer the following questions:

1. Are *C. cricetus* densities higher in sown wildflower fields compared to agricultural crops?
2. Is there a concentration of *C. cricetus* in sown wildflower fields or are hamsters equally distributed in adjacent agricultural crops around sown wildflower fields?
3. What local and landscape scale parameters of sown wildflower fields determine *C. cricetus* densities and its occurrence probability?

2. Material and methods

2.1. Study area

The study was conducted between the end of May and end of June 2013 in North-West Bavaria in Lower Franconia between Schweinfurt and Würzburg (centred at 49°49′ N, 11°09′ E), the main distribution range of *C. cricetus* in Bavaria (Fig. A.1; Schreiber, 2010). The study area had a maximal extension of 50 km from north to south and 20 km from east to west around the study centre. The study area in Lower Franconia was selected as it is known that hamsters are present throughout the whole area due to deep loess and loess loam soils (Schreiber, 2010). The landscape of the study area was characterized by 42% winter cereals, 2% permanent grassland, 0.83% wildflower fields and 0.32% alfalfa (in total 81% agricultural land including arable land, permanent crops and pastures), 10% artificial surfaces (urban fabric, industrial and transport units, artificial non-agricultural vegetated areas), 5% forest cover, 1% semi-natural areas, and 3% other landscape elements.

In the study area sown flower-rich fields (hereafter referred to as "wildflower fields"), but not wildflower strips, were chosen, which were funded in the frame of the Cultural Landscape Program — Part A (KULAP-A) between 2007 and 2013 in Bavaria to implement agro-ecological concepts on arable land. In the course of this measure, 19 000 wildflower fields with a mean field size of 1.13 ha were established between 2008 and 2010, commonly on (less-favored) arable land. Seed mixtures contained annual and perennial wild and cultivated plants, intermixed with e.g. sunflowers (*Helianthus annuus*), fennel (*Foeniculum vulgare*), mallow (*Malva* spp.) and chicory (*Cichorium intybus*), providing a high vegetation cover during the whole vegetation period. Wildflower fields received no further management over a period of 5 years, no applications of pesticides, synthetic fertilizers, tillage and mowing (StMELF, 2011; Wagner et al., 2014).

2.2. Wildflower fields vs. agricultural fields

To compare *C. cricetus* densities in wildflower fields and agricultural fields, we randomly selected 14 wildflower fields paired with an agricultural field of comparable size, respectively. Minimum distance between paired fields was 200 m, exceeding mean movement distances of 130 m of male hamsters during their activity period (Kupfernagel, 2007). To study concentration effects in wildflower fields and the distribution of hamsters in adjacent agricultural fields, additional agricultural fields bordering the 14 paired fields (wildflower and agricultural fields) were mapped up to a distance of 200 m in a standardized direction (southward). This area was divided into four adjacent subplots with 50 m width each (Fig. 1). So we had a sequence of subplots with a distance of 0, 50, 100, 150 and 200 m from the study field (2 paired fields × 14 pairs × 5 subplots; $n = 140$). Fields were chosen according to the soil quality, selecting areas with deep loess and loess loam soils. Furthermore, fields had a minimum distance of 400 m to forests and 200 m to settlements and transport units (road and rail networks) to reduce an increasing mortality risk through predators (Kayser et al., 2003), as well as through traffic accidents (Hell et al., 2005). To control for effects of crop type of agricultural fields, previous crop types from