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Response of small mammals to variable agricultural landscapes in Central Europe

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ABSTRACT

The Central European agricultural landscape has undergone a number of changes over recent decades, with overall field area decreasing and adjacent habitats increasing. Here, we document changes in small mammal communities associated with crop fields and adjacent fallow land in a highly agriculture landscape of the Czech Republic.

The most numerous species overall were wood mice (*Apodemus sylvaticus*) and common voles (*Microtus arvalis*). Highest diversity, species richness and abundance were observed in fallow habitats and in crops providing long-term vegetation cover. Community composition and abundance were dependent on crop and season. Mice used all habitats depending on instantaneous vegetation stage, though some habitats only for a short period during seeding or harvest. Common voles reached highest densities in habitats providing a stable food supply. Mice and voles both preferred perennial "non-crop" plots during winter as they provided a diverse food supply and undisturbed nesting opportunities.

Overall, fallow habitats supported the most abundant, diverse and stable small mammal communities and, as such, they have high biodiversity value.

Introduction

Agricultural landscapes consisting of a mosaic of crops, set-aside and abandoned agricultural landscapes are now common in Europe. In Central Europe, economic and sociological changes over the last two decades have resulted in many changes in the landscape, with large field plots now divided into smaller units and the number and size of habitat types that increase agricultural landscape diversity (De la Pena et al., 2003; Butet et al., 2006), such as un-ploughed non-crop fields, herbaceous set-aside and abandoned orchards, have been increasing (Czech statistical Office: https://www.czso.cz/csu/czso/zem_ts). Alongside the introduction of fallow habitats, crop composition has also changed in Central Europe, with a significant increase in the cultivation of oil crops such as sunflower, maize and rape. Indeed, rape is now one of the dominant crops in the Czech Republic (Czech statistical Office: https://www.czso.cz/csu/czso/zem_ts).

Finally, new practices, such as increasing the amount of land set-aside, have been introduced under the European Union's (EU) Agri-Environmental Scheme that aim to mitigate the impact of intensive agricultural practices (Broughton et al., 2014).

It is generally believed that rodent populations in fallow habitats are not so drastically influenced by intensive agro-technical management as those in crop fields. Such habitats, which include windbreaks, small forests, riparian strips and road verges, display increased plant and animal species diversity and can act as stabilising elements in the landscape (Schwartz and Whitson, 1987; Sotherton, 1998) as the wide food spectrum available in such plots is capable of supporting a range of herbivorous, granivorous and insectivorous species (Ylonen et al., 1991; Giraudoux et al., 1994; Sotherton, 1998). Set-aside plots also act as a spatial refuges for animals until potentially harmful farm activities (e.g. ploughing) cease or, alternatively, as 'trophic storehouses' against times when food in cultivated fields is limited (Ylonen et al., 1991; Maisonneuve and Rioux, 2001). Such changes in the landscape are also likely to be reflected in the composition and abundance of small mammal communities, however, which can then become important agricultural

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pests. Indeed, pest and weed problems are often cited as the main risks of fallow field management (Firbank et al., 1993). This is especially true of granivorous species such as Apodemus sp., which can successfully colonise adjacent crop fields (Bryja and Zukal, 2000; Tattersall et al., 2001) and become an important pest species of seed-bearing crops (Heroldova et al., 2004). Numerous studies in the United Kingdom (e.g. Tew and Macdonald, 1993; Tattersall et al., 1999; Todd et al., 2000) and Scandinavia (e.g. Loman, 1991) have documented the effect of crop composition and the presence, proportion and size of fallow habitat and small hedgerows on small mammal communities in the landscape. Most of these studies, however, focused on the wood mouse (*Apodemus sylvaticus*, Linnaeus, 1758) as it was the most dominant species in these parts of Europe. In Central Europe, the common vole (*Microtus arvalis*, Pallas, 1778) is also found in high numbers and represents one of the most important rodent pests in Central Europe (Zejda and Nesvadbova, 2000; Zejda et al., 2002). The majority of small mammal studies from Central Europe, however, were undertaken some years ago and do not reflect recent changes in crop and landscape composition. Furthermore, they tend to focus on small mammals in more traditional crops; hence, little or no data is available for small mammals in fallow habitats, maize, rape or sunflower (but see Truszkowski, 1982; Aschwanden et al., 2007; Jacob et al., 2014). As a result, there is only limited information available on the species composition, number and reproduction of small mammals in such habitats, no least as such communities can show dynamic changes in composition and size through the year. Hence, there is a clear need for new in-depth studies in fallow and crop habitats examining small mammal population growth and density fluctuation, along with a clarification of the role of fallow plots on small mammal demography. The resultant empirical data could be of great importance for future agro-eco landscape management.

The aim of this study, therefore, was to compare the composition and demography of rodent communities in crop fields and adjacent fallow habitats and to assess the diversity and ecological value of the habitats. Four hypotheses were tested:

1. Small mammal species richness and diversity will differ in different habitats, with highest biodiversity expected in perennial habitats with diverse vegetation cover.
2. Small mammal abundance will differ in different habitat types, with constant species-specific preferences shown for particular crops. Habitat preference may remain consistent over subsequent years.
3. Fallow sites are important habitats for small mammals and species richness and diversity will be higher in such plots. Seasonal abundance will not vary as much as in cultivated crops due to a more constant food supply.
4. Differences in small mammal abundance will be caused by changes in reproduction rate, with increased reproduction in habitats with higher abundance.

Material and methods

Sampling took place between 2008 and 2010 in a mixed agricultural landscape near the village of Nosislav in the South Moravian Pannonian lowland, Czech Republic. While the exact location of the fields changed each year according to the agricultural corporation's sowing plans, all study plots were within the area covered by GPS coordinates 49°00′77 N–49°03′99 N and 16°65′72 E–16°68′43 E, with no plot more than 6 km from another. The landscape is relatively uniform and, while there is no forest within 10 km, there are several small wooded windbreaks.

Trapping took place in alfalfa, spring barley, maize, winter rape, sunflower and winter wheat fields, as well as in fallow habitats comprising steppe-type set-aside and old abandoned orchards. In addition to the old trees, old orchard vegetation comprised early stage shrubby succession of dog-rose (*Rosa canina,* L.) and blackthorn (*Prunus spinose,* L.). The dominant species in the understory included grasses (20% cover), stinging nettle (*Urtica dioica,* L.), garlic mustard (*Alliaria officinalis,* M. Bieb.) and herb bennet (*Geum urbanum,* L.). Herbal set-aside plots, which were managed and cut according to EU recommendations (see Broughton et al., 2014), were mainly covered by grasses (>80%), including oat-grass (*Arrhenatherium elatius,* L.), common meadow-grass (*Poa pratensis,* L.), brome grass (*Bromus* sp.) and chee reedgrass (*Calamagrostis epigeios,* L.). Dicotyledons were represented by sickleweed (*Falcaria vulgaris,* Bernh.), white bedstraw (*Galium album,* L.), yarrow (*Achillea millefolium,* L.) and white campion (*Silene latifolia,* Mill.).

As the small mammals captured were also to be used for research on presence of rodent-borne diseases (Treml et al., 2012) and food quality (Janova et al., 2016), it was decided to use snap-traps baited with wicks soaked in fat and flour and fried. Habitats with perennial vegetation (alfalfa, fallow habitats, set-aside and old orchards) were sampled over the whole year. Other crops were sampled while biomass was available as a potential food source, usually until deep ploughing following the harvest. Perennial rape was sampled from the autumnal sowing until ploughing in August. Winter wheat, which is usually sown over multiple years on the same field with biomass often remaining on the field until the next sowing, was sampled over most of the year, except for a short period between ploughing and sowing. No sampling took place during snow cover as this affected rodent trapability (Kratochvil, 1959). All habitats were sampled simultaneously on the same date in order to reduce the influence of weather on the results. Sampling took place every four weeks during the growing season (April–October), and every six weeks out of the growing season, in all crops and fallow plots simultaneously. Traps were exposed for two nights in a line comprising 50 traps spaced three-metres apart. In total, 27 trapping sessions were performed, ten sessions in 2008, nine in 2009 and eight in 2010 (for more details see Table 1). In most cases, more than two fields of each crop or habitat type were available in the area sampled, in which case the trap line positions were rotated to a different field each sampling. If this was not possible, trap lines were subsequently laid in a different part of the field. All fields used were greater than 100 × 200 m. Distances between trap lines in the same field (at least 200 m) and distances to lines in the nearest crop were always long enough to consider the trap lines as independent. The relatively low trapping effort overall ensured that subsequent results were not biased by population reduction, captured individuals soon being replaced through recruitment and immigration.

All individuals captured were identified to species, weighed (g), sexed, measured (mm) and dissected. Special attention was given to distinguishing wood mice (*Apodemus sylvaticus*) and yellow-necked mice, which were distinguish using parameters of hind legs, ear size and skull (Jojic et al., 2014). Community diversity was calculated for each crop using the Shannon diversity index (Shannon and Weaver, 1949; Spellerberg and Fedor 2003). Species richness was estimated for each habitat as the number of species captured. Population size for each trapping line was estimated as relative abundance, i.e. the number of individuals caught in the field per hundred trap-nights. In our case, this was the number of individuals captured over two subsequent nights in 50 snap-traps. For the purposes of this study, we assessed relative abundance for the two most commonly captured species only. The influence of year and crop (categorical predictors), date of trapping (continuous predictor) and interaction between year and habitat on the relative abundance of the two most common species were tested using a multivariate general linear model (GLM). Differences in the numbers caught each year and between different crops were analysed