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# Organic farms as refuges for small mammal biodiversity in agro ecosystems

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**Abstract**

Habitat fragmentation, the process by which relatively continuous habitats is broken into smaller pieces, occurs in natural systems but is to a high degree also human-induced through landscape use. Fragmentation of the landscape produces a series of habitat patches surrounded by a matrix of different habitats and land use regimes. The major landscape consequences of fragmentation are loss of habitat, reduction in habitat patch size, and increasing isolation of habitat patches. In general, population performance declines in response to habitat loss but size of remaining area and isolation effects is known also to influence the population trend. Small mammals are well suited for examination of population responses to habitat fragmentation as they have modest spatial requirements and short generation times.

In theory, organic farms could play an important role in the agricultural landscape as refuges for some small mammal species, as the lack of pesticide and fertiliser treatment, less weed control, more diversified crop structure and a general environmental friendly attitude, form a basis for habitats that provide cover and food for small mammals, and thus for larger predators of these species. Furthermore, density and area of small biotopes could be expected to be higher in the organic farms, thus leading to a decreased distance between optimal habitats.

This study compares species diversity and abundance of small mammals in conventional farms and intensively and extensively grown organic farms. In a wide range of different fields in conventional and organic farms, the diversity and density of small mammals were investigated by live-trapping sessions, comprising trap lines with 15 meters between each trap. We studied the responses of populations (belonging to 11 species of small mammals) to habitat patches of different size and different surrounding management strategies (ecological and conventional farming).

We found a general correlation between the number of small mammal individuals and small biotope size. This correlation applies in autumn as well as in spring. There is only a weak tendency for more small mammals in small biotopes within organic farms compared within conventional farms. The number of small mammal species stabilises at small biotope sizes around 1000 square meters. The value of organic farms in respect to small mammal biodiversity depends mainly upon the number and area of small biotopes, and only to a minor degree upon the treatments of the fields.

## Introduction

In North Western Europe, conventional farming has, especially through the last 3-4 decades, altered the landscapes considerably by changing unproductive areas into productive farmland, thus creating large fields and leaving only few small unproductive biotopes. Moreover conventional farming has increased use of pesticides and fertilisers which not only influence the fields themselves but also neighbouring biotopes. This has had dramatic, negative effects on flora and fauna in the agricultural landscape (Robinson & Sutherland 2002, Bengtsson et al. 2005, Geiger et al. 2010).

In contrast, organic farming, with restricted use of pesticides and mineral fertilizers, has been promoted as a more biodiversity friendly management, however, the overall effectiveness of organic farming varies among taxa (Bengtsson et al 2005, Fuller et al 2005, Hole et al 2005). Also, the effects of landscape composition have been shown to be more important than the farming practice (Weibull et al 2003, Purtauf et al 2005, Aavik & Liira 2010, Winqvist et al 2010).

Habitat fragmentation, the process by which relatively continuous habitats is broken into smaller pieces, occurs in natural systems but is to a high degree also human-induced through landscape use. Fragmentation of the landscape produces a series of habitat patches surrounded by a matrix of different habitats and/or land use regimes. The major landscape consequences of fragmentation are loss of habitat, reduction in habitat patch size, and isolation of habitat patches. Furthermore, it is expected that density and area of small biotopes are higher in the organic farms, thus leading to a decreased distance between optimal habitats.

Population performance in general may decline in response to habitat loss but size of remaining area and isolation effects is known also to influence the population trend. Decline in population size will be greater than expected from habitat loss alone due to factors such as emigration exceeding immigration, lower survival rate as demographic stochasticity increases, restriction of animal mobility because of isolation by distance, and their spatial requirements. This leads to the prediction that population performance should decline with fragmented habitat size and habitat isolation in a highly fragmented landscape. Small mammals are well suited for examination of population responses to habitat fragmentation as they have modest spatial requirements and short generation times.

This study compared species diversity, abundance and reproduction of small mammals in conventional farms and intensively and extensively managed organic farms. We hypothesized that organic farms could play an important role in the agricultural landscape as refuges for some animal species, especially small mammals, as the lack of pesticide and fertiliser treatment, less weed control, more diversified crop structure and a general environmental-friendly attitude, could form a basis for habitats that provide cover and food for small mammals, and thus for larger predators of these species as well.

## Materials and methods

The diversity and density of small mammals were investigated by trapping sessions in a wide range of different fields in conventional and organic farms. We studied the responses of populations (belonging to 11 species of small mammals) to habitat patches of different size and different surrounding management strategies (ecological and conventional farming).

Studies were performed in central and eastern Jutland, Denmark, viz. near the towns of Bjerringbro and Rønde and Lake Fussingø. The areas are representative of Danish farmland in respect to crop types, soil structure, fertility and land management (Dalgaard 2011).

Generally, conventional farms were either plant growing entities having large fields of winter wheat, winter oilseed rape and spring barley in short rotation or cattle farms with grass fields, maize and other fodder crops. There were few hedge rows, water ponds and other small biotopes.  In contrast, organic farms had smaller fields with a diversity of crops in longer rotation and a larger number of small biotopes.

The diversity and density of small mammals were investigated by trapping sessions in a wide range of different habitats surrounding fields in rotation in conventional and organic farms. Eight different areas were chosen for intensive trapping, four in conventional fields and the other four in organic fields. Fifteen small biotopes were studied, 8 in organic farms and 7 in conventional farms, including different types of tree-covered habitats, e.g. hedgerows, wildlife refuges, surroundings of ponds and burial mounds.

Two main types were investigated, viz. tree-covered small habitats and grassland. These small biotopes had very different ground cover, tree and scrub composition, etc. For statistical analysis we described each trap line in regard to habitat size, vegetation, and distance to similar habitat.

Traps designed to capture various small mammal species (type Ugglan, Grahnab Sweden) baited with rolled oats and apple) were used for live trapping which was performed in trap lines consisting of at least 10  traps at 15 meter intervals between each trap, unless the habitat investigated was small. A total of 50 trap lines were operated. The trapping sessions were performed spring/early summer (before harvest), late summer/autumn (after harvest) and late autumn/winter (after winter sowing).

**Results**

*Species composition*. The Danish small mammal fauna consists of 17 species, 14 of which are found in the general area and in the habitat types investigated.  In the present study we recorded 13 species of small mammals, only water vole (*Arvicola terrestris*) was not recorded.

Hedge rows between fields contained 10 species. Bank voles (*Myodes glareolus*) and Harvest mice (*Micromys minutus*) were dominant rodents and overall found in highest numbers in hedge rows within organic farms. Co-dominant was Common shrew (*Sorex araneus*), which did not show any significant difference between management types (fig. 1).

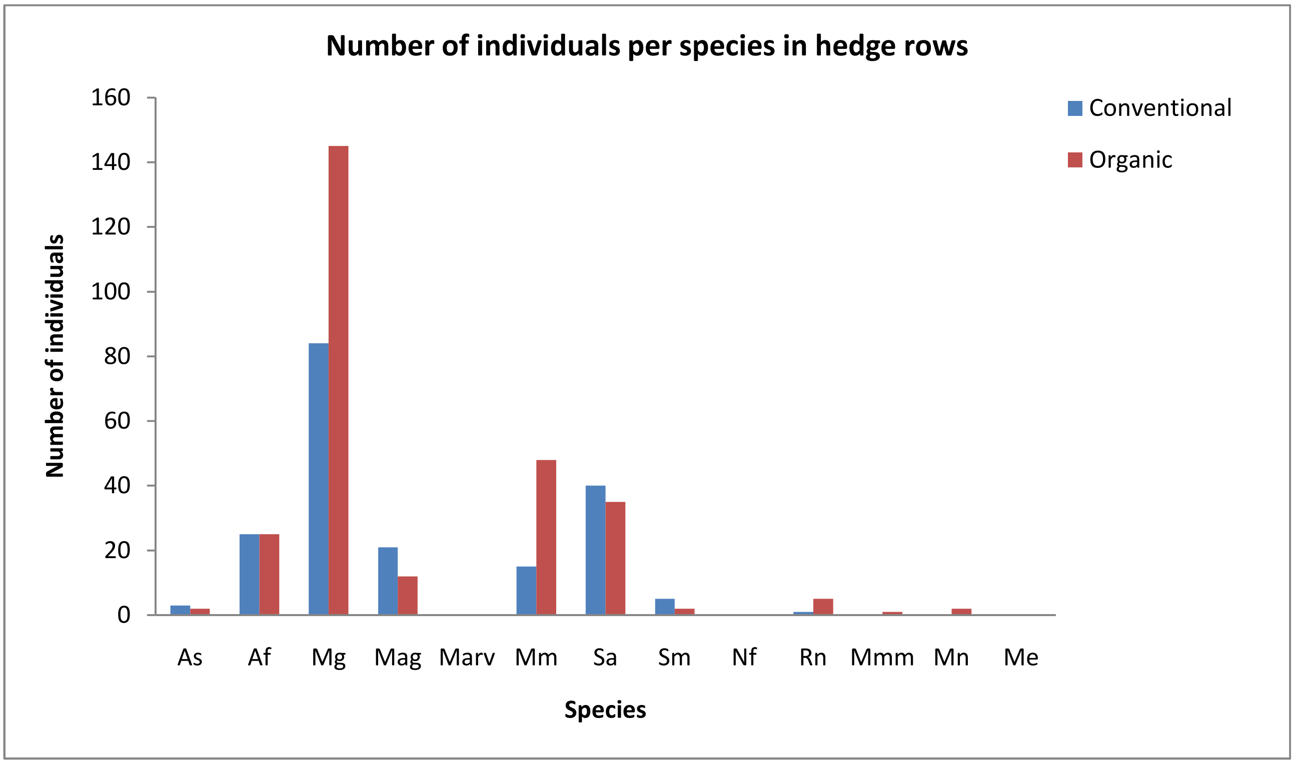


Fig. 1. The number of individuals of various small mammal species in hedge rows within conventional (n= 194) and organic farms (n=277). Legend: As: *Apodemus sylvaticus*; Af: *A. flavicollis*; Mg: *Myodes glareolus*; Mag: *Microtus agrestis*; Marv: *M. arvalis*; Mm: *Micromys minutus*; Sa: *Sorex araneus*; Sm: *S.minutus*; Nf: *Neomys fodiens*; Rn: *Rattus norvegicus*; Mmm: *Mus musculus musculus*; Mn: *Mustela nivalis*; Me: *M.erminea.*

Grassland fields and meadows contained 10 species. Fig. 2 shows that in grassland habitats field voles (*Microtus agrestis*), Harvest mice (*Micromys minutus*), Common shrews (Sorex *araneus*) and Pygmy shrews (*Sorex minutus*) were dominant and overall found in highest numbers within organic farms.

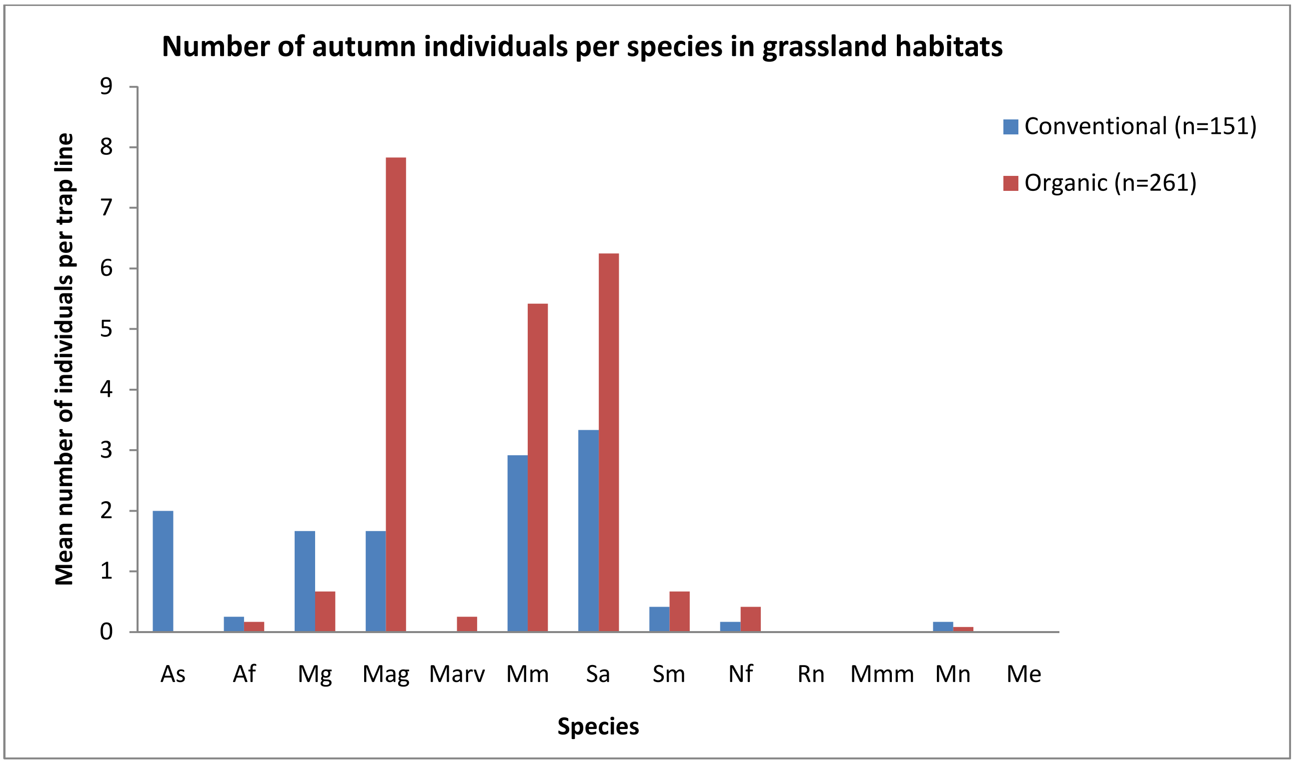


Fig 2. The number of individuals of various small mammal species in grassland within conventional and organic farms. Legend: As: *Apodemus sylvaticus*; Af: *A. flavicollis*; Mg: *Myodes glareolus*; Mag: *Microtus agrestis*; Marv: *M. arvalis*; Mm: *Micromys minutus*; Sa: *Sorex araneus*; Sm: *S.minutus*; Nf: *Neomys fodiens*; Rn: *Rattus norvegicus*; Mmm: *Mus musculus musculus*; Mn: *Mustela nivalis*; Me: *M.erminea*.

Studies were performed mainly in tree-covered habitats surrounded by open fields, e.g. on dry hills, around moist meadows and isolated hedgerows. In each habitat only up to 6 species were trapped. The number of species depended upon the size of the habitat, i.e. more species were recorded in larger habitats. Fig. 3 shows that a saturation point of around 6 species is reached already at patch levels around 1000 square meters. There was no significant difference between farming systems.

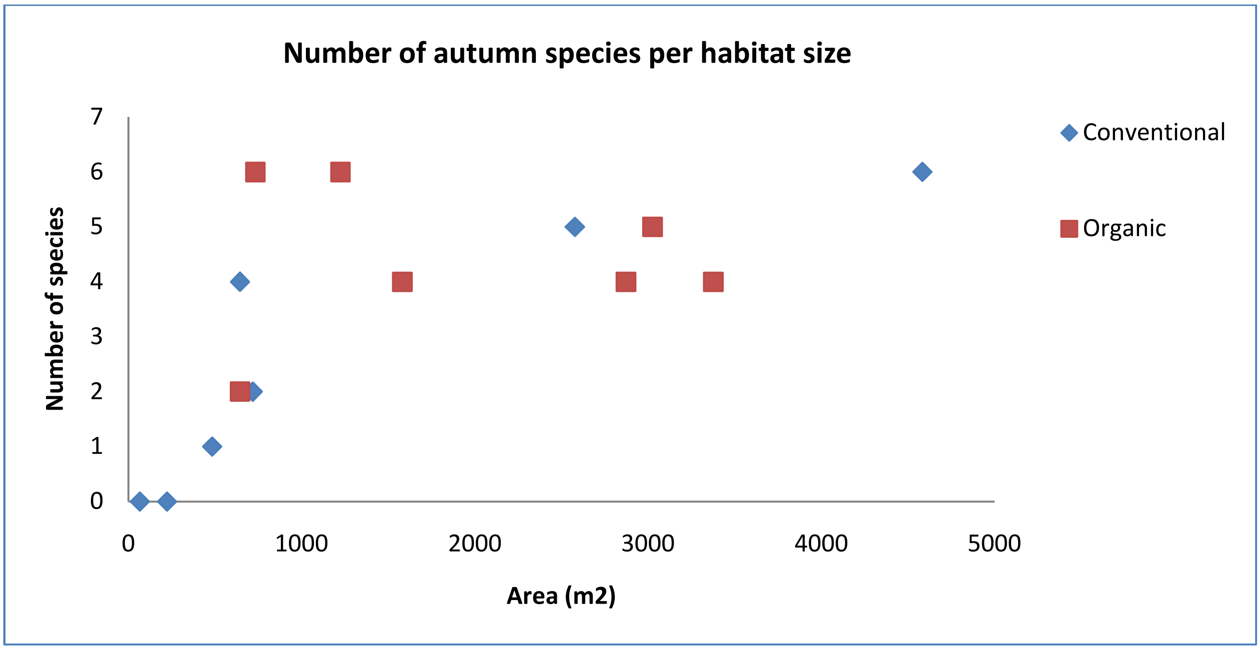


Fig. 3. The number of small mammal species in small biotopes within organic and conventional farms in relation to habitat patch size.

*Population levels*

For the total number of individuals (all species) population levels were higher in all patches during autumn than during spring as a result of mortality during the non-reproductive winter period. In spring several small patches were without small mammals. In both spring and autumn there was a positive correlation between numbers and the total number of small mammal individuals per habitat patch (fig 4).

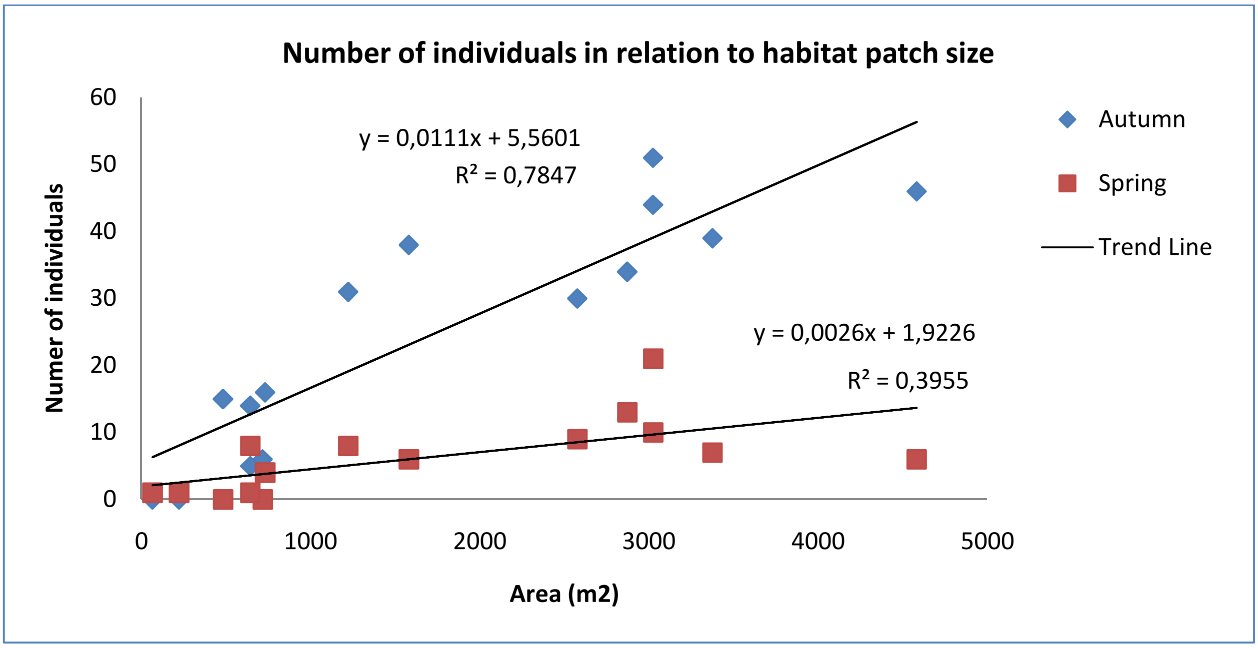


Fig. 4. The number of small mammal individuals (all species) in relation to habitat patch (sqm) during autumn and spring.

When the number of autumn individuals within conventionally managed farms was compared with organically managed arms we found that, generally, small biotopes within organic farms tended to have higher densities of small mammals. This trend was, however, not significant (fig. 5).

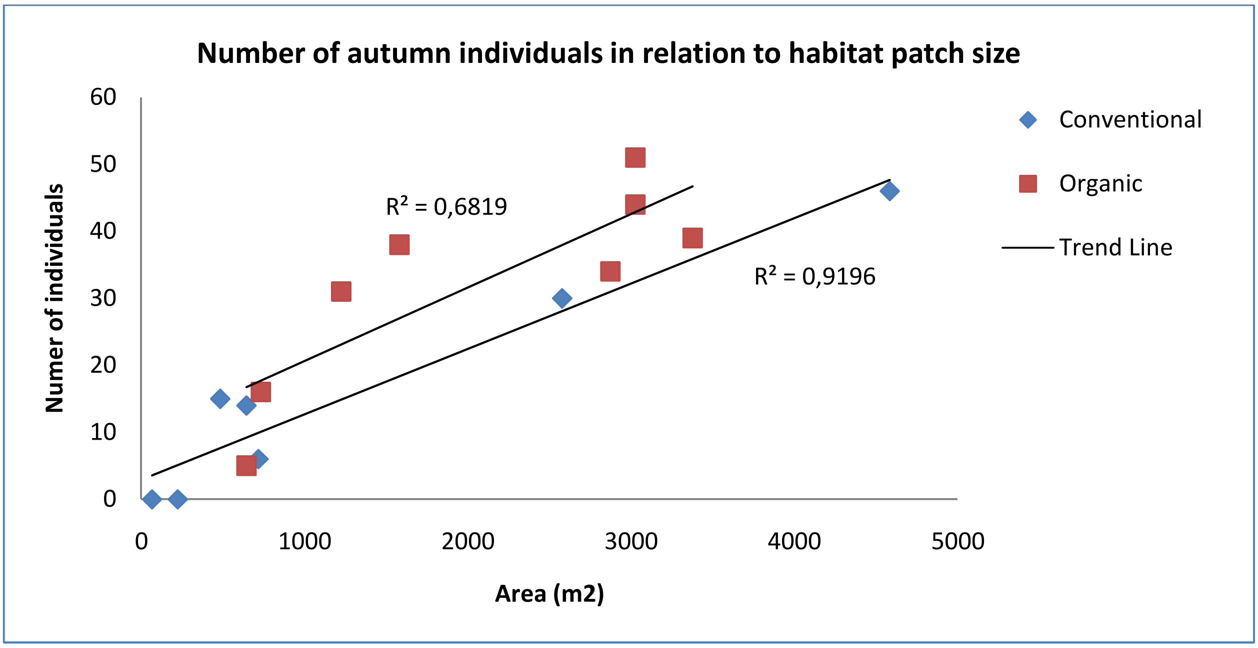


Fig. 5. Autumn trap line number of individuals (all species) in relation to small biotope patch size within conventional and organic farms.

Similarly, in spring small biotopes within organic farms tended to have higher densities of small mammals than within conventional managed farms, however numbers were not statistically significantly different (Fig. 6).

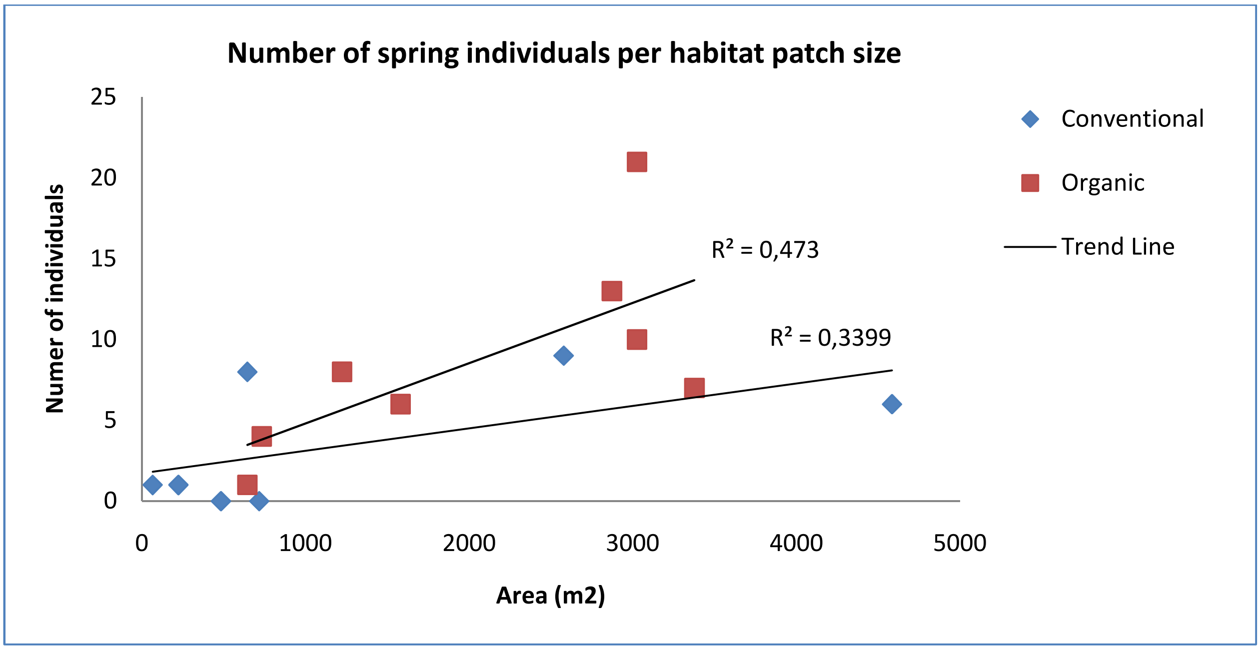


Fig 6. Spring numbers of individuals (all species) in relation to small biotope patch size within conventional and organic farms.

**Discussion**

In the present study we found few differences in species composition and in the number of individuals per species between conventional and organic farms, neither in grassland nor in hedges. In crops numbers were so low that comparisons were not possible.

Bank vole was the dominant species in hedge rows and occurred in higher number in organic farms, a difference which probably can be ascribed to a more dense cover, as ground vegetation in conventional hedges is influenced by herbicides drifting from treated field crops. In addition, trees and bushes treated with herbicide carry fewer berries and hence offer less food for this granivorous species. Harvest mice, another a granivorous species, also occurred in higher numbers in organic hedge rows, probably also an effect of better vegetation cover and higher seed production. In contrast the predatory common shrew did not show significant differences between organic and conventionally managed hedges.

In grassland, field voles dominated and occurred in much higher numbers in organic farms than in conventional farms. We hypothesize that it is a more diverse vegetation composition with more deciduous herbs that are found in the organic grassland due to the lack of herbicides, and field voles prefer dicots in their diet. The higher numbers of harvest mice could be due to a more dense and higher vegetation. Common shrews were also captured in higher numbers in organic grassland, probably because dense vegetation has higher numbers of invertebrates which this species prefer.

The number of small mammal species increased with increasing patch size in accordance with general biogeographical theory (McArthur and Wilson 1967), however there was no significant difference between conventional and organic farms. This indicates that it is more the structure of the patches and the landscape structure rather than the management treatment that determine species numbers.

According to metacommunity theory, the number of species present at a given site does not only reflect local environmental conditions, but also the connectivity to adjacent sites. A fundamental aspect of metacommunity theory is the existence of dispersal limitation. For example, experiments with terrestrial plant communities showed that local species richness of natural communities increased once seed dispersal is increased (Turnbull et al. 2000). Thus, the number of taxa present at a given site reflects steady-state colonization-extinction dynamics (Vandvik & Goldberg 2006). Highly mobile organisms are generally expected to have metacommunities spanning larger spatial scales than less mobile organisms (Jenkins et al 2007). The relative importance of local versus regional environmental factors in controlling local species richness thus depends among others on the dispersal rate and mobility. The apparently high dispersal capabilities in natural habitats has been the basis for assuming that dispersal limitations is irrelevant for structuring small mammal communities, but when fragmentation sets in and creates dispersal barriers the species composition of small mammal species may become under saturated.

**Acknowledgements**

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