**Original Paper**

# Distribution of Small Mammals (Eulipotyphla, Rodentia) under Organic and Conventional Farming Conditions

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Article Details: Received: 2024-09-07 | Accepted: 2024-11-25 | Available online: 2025-03-31

https://doi.org/10.15414/afz.2025.28.01.21-27



Agricultural land is important for the biodiversity of small mammals, their modifications in the spatial structure also indicates the quality of the agroecosystem. Different methods of land management (organic and conventional) affects their heterogeneity, which also affects crop yield. The goal of our research was to determine changes in the spatial structure of small mammals under conditions of organic and conventional farming. Crops grown in organic farming were *Pisum sativum*, *Triticum spelta*, Clover grass mix and *Zea mays*, *Triticum aestivum* and *Brassica napus* in conventional farming. Between the years 2019 and 2023, with the help of pitfall traps, they recorded a total of 195 individuals and 6 species (*Apodemus sylvaticus*, *Micromys minutus*, *Microtus arvalis*, *Crocidura leucodon*, *Sorex araneus*, *Sorex minutus*). We confirmed 6 species and 95 small mammal individuals in organic farming; 5 species and 100 small mammal individuals in conventional farming. Multivariate analysis (PCA) confirmed the preference of small mammals for organic farming crops. A significant influence of temperature and moisture on the spatial dispersion of small mammals was found using redundancy analysis (RDA). One more species in each type of management was predicted using the rarefaction curves. From the results of our research, we can say that small mammals preferred the conditions of organic farming, which points to better topical and tropical conditions for them in this type of farming.

**Keywords:** agroecosystems, management crops, small mammals, diversity, Slovakia

## 1 Introduction

There are 30% more species and 50% more individuals in organically grown crops compared to conventional farming. Birds, predatory insects, spiders and organisms living in the soil and field flora benefit the most from this type of management (Bengtsson et al., 2005).

Organic farming in combination with semi-natural biotopes can contribute to improving the number of species. Rare species of plants and animals also have a higher diversity and density on Organic Agricultural Land (Crowder et al., 2010). Agriculturally, a variety of organisms are needed to support essential ecosystem services, such as pest control and pollination, that contribute to crop yields. Organic farming increases the heterogeneity of crops and landscapes, thus forming one of the main components of a land use strategy, providing wider ecosystem services, including the protection of culturally important species (Gabriel et al., 2013; Tscharntke, et al., 2012). Although it is confirmed that organic farming has greater biodiversity compared to conventional farming, the intensity of the effect can be different between species in the country (Batáry et al., 2011). Bengtsson et al. (2005) found the greatest effect in intensively managed agricultural landscapes, while Tscharntke et al., (2005) confirmed it in a simple landscape structure as in a heterogeneous agrarian landscape.

Conventional farming is used all over the world, on the basis of which soil degradation occurs and thus also endangers the environment and negatively affects sustainable agriculture (Montgomery, 2007). The use of pesticides and artificial fertilizers leads to a gradual

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increase in soil salinity and the volume of nitrogen, which leads to its leaching and subsequent contamination of groundwater. As a result of these activities, there is a decrease in the biodiversity of fauna and flora and their abundance (Sharma, 2011). Toxic substances found in pesticides accumulate in crops, the products of which are subsequently consumed by consumers, which leads to various diseases (Briones and Schmidt, 2017; Simão et al., 2015).

Small mammals represent an important group of fauna in the food chains of agroecosystems, they participate in the spread of plant seeds and mycorrhizal fungi, they eat various arthropods. On the other hand, they are the main pests of agricultural crops (Guidobono et al., 2019; Benedek and Sirbu 2018). Their life cycle is short and they respond quickly to management adjustments in agroecosystems, therefore they are good model organisms for understanding the impact of mechanisation and management in agrarian land (Balčiauskas et al., 2019). In this group of animals there are species that are eurytopic, but also specialists that occur only in certain types of habitats. Stenotopic species occur only in habitats with specific conditions, but general species of small mammals do not have a specific link to habitats in agriculturally used land (Stirkė et al., 2022; Martínez et al., 2014).

*Microtus arvalis* (Pallas, 1778), which is an important element of agroecosystems in Central Europe, is a frequently occurring species in agricultural crops. It serves as food for more than 40 species of predators, its burrowing activity aerates the agricultural soil, which helps retain moisture in the soil (Bashlykova and Korolev, 2014). Another fact is that when overpopulated, this species causes significant economic damage to farmers. The spread of this species is conditioned by processes of natural dispersion but also by the transformation of areas into agroecosystems. Thus, the processes of expanding agrocenoses also influenced the increase in the distribution area of *Microtus arvalis* in Eastern

**Figure 1** Map of agricultural areas where the research took source place
Source: Google Earth

Europe (Malygin et al., 2020; Khlyap and Warshavsky, 2010).

We expect that our results will contribute to new information about the dispersal of individual Araneae in ecological and conventional farming conditions.

## 2 Material and Methods

The research was conducted between the years 2019 and 2023 on 6 types of crops and their grass-herb strip (GHS). *Pisum sativum*, *Triticum spelta* and Clover grass mix (CGM) crops were grown in Organic farming. In conventional farming, these were the following crops: *Zea mays*, *Triticum aestivum* and *Brassica napus* (Figure 1). The fields where organic farming crops were grown belonged to the company ECO-Farm Nitra, s.r.o. Crops grown by conventional farming belonged to IMRIŠEK s.r.o. 5 pitfall traps and their CGM were placed in lines on each field. There was a distance of 10 m between each trap so this represented a 40 m long line of pitfall traps. We used 4% formaldehyde solution as a fixation liquid. We collected pitfall traps at regular monthly intervals. We determined the obtained species of Small Mammals according to Baláž et al. (2013). We measured pH, temperature and soil moisture variables using Dexxer PH-03 and Rapitest 3 1,835 meters.

The studied fields are located near the city of Nitra (south-western part of Slovakia), at an altitude of 138 m above sea level (coordinates: 48° 17′ 12″ N 18° 6′ 35″ E). The territory falls under a warm and dry climate with mild winters. The soil type is brown soil.

The principal component analysis (PCA) was used to determine the relationship between species and crops with their grass-herb strip (GHS). The influence of environmental variables (soil temperature, moisture and pH) on Small Mammals was determined using redundancy analysis (RDA). We tested the statistical significance of environmental variables using the Monte Carlo test (iteration 499) in the Canoco5 programme (Ter Braak and Šmilauer, 2012). Analysis in the statistical programme R version 4.1.3. was focused on Rarefaction curves.

## 2 Results and Discussion

A total of 195 individuals belonging to 6 species of small mammals and to 2 families on the investigated agricultural crops was recorded. The Muridae family includes the species *Apodemus sylvaticus*, *Micromys minutus* and *Microtus arvalis*. The Sorecidae family is represented by the species *Crocidura leucodon*, *Sorex araneus* and *Sorex minutus*. The eudominant representation in both types of management had the species *Microtus arvalis* (organic = 75.8%, conventional = 81%). The least represented species in organic farming had *Micromys minutus* (2.1%) and *Sorex araneus* (2.1%) and *Apodemus sylvaticus* (3%) and *Sorex minutus* (2%) in conventional farming (Table 1). An increased number of small mammals leads to disruption of the agroecosystem where they act as pests. In agricultural landscapes, they are still exposed to anthropogenic activity, environmental changes and types of crops. All these factors affect their spatial dispersion (Jurišič, 2021; Tschumi et al., 2018). Gómez et al. (2018)

**Table 1** Species representation of Small Mammals between the years 2019 and 2023

| Farming/ familia | Species | Years | | | | | Σ individuals | % |
|---|---|---|---|---|---|---|---|---|
| | | 2019 | 2020 | 2021 | 2022 | 2023 | | |
| Organic | | 3 | 16 | 22 | 18 | 36 | 95 | 48.70 |
| Muridae | *Apodemus sylvaticus* (Linnaeus, 1758) | - | - | - | 1 | 3 | 4 | 4.20 |
| | *Micromys minutus* (Pallas, 1771) | - | - | - | - | 2 | 2 | 2.10 |
| | *Microtus arvalis* (Pallas, 1778) | 3 | 13 | 21 | 9 | 26 | 72 | 75.80 |
| Sorecidae | *Crocidura leucodon* (Hermann, 1780) | - | 3 | 1 | - | 4 | 8 | 8.40 |
| | *Sorex araneus* (Linnaeus, 1758) | - | - | - | 2 | - | 2 | 2.10 |
| | *Sorex minutus* (Linnaeus, 1766) | - | - | - | 6 | 1 | 7 | 7.40 |
| Conventional | | 28 | 17 | 11 | 9 | 35 | 100 | 51.28% |
| Muridae | *Apodemus sylvaticus* (Linnaeus, 1758) | - | 2 | - | 1 | - | 3 | 3.00 |
| | *Micromys minutus* (Pallas, 1771) | 3 | - | - | - | 4 | 7 | 7.00 |
| | *Microtus arvalis* (Pallas, 1778) | 23 | 13 | 11 | 8 | 26 | 81 | 81.00 |
| Sorecidae | *Crocidura leucodon* Hermann, 1780 | 2 | 1 | - | - | 4 | 7 | 7.00 |
| | *Sorex minutus* (Linnaeus, 1766) | - | 1 | - | - | 1 | 2 | 2.00 |
| Σ individuals | | 31 | 33 | 33 | 27 | 71 | 195 | 100.00 |

dealt with the impact of biotopes and management activities on small mammals, where they confirmed that there is a connection when detecting species on the site, and the impact of the management of agrarian land on their dispersion is complex.

Using principal component analysis (PCA, SD = 2), we determined the relationship of species to crops (*Pisum sativum*, *Triticum aestivum*, *T. spelta*, *Zea mays*, *Brassica napus*, Clover grass mix (CGM)) and their grass-herb strip (GHS). The variability of taxa was 62.8% on the first ordination axis and 78.5% on the second cumulative axis. On the ordination graph, we can see that the Small Mammal species preferred the conditions of the crops and their grass-herb strip grown in organic farming (Figure 2). The plant composition of fields is determined by their management, pests, diseases, weeds and soil. The spatial dispersion of small mammals in fields is influenced by the aforementioned factors as well as the plant composition of the fields themselves (Coda et al., 2016; Haddaway et al., 2016). From the PCA analysis, we confirmed the species' preference for ecologically grown crops and their GHS representing more natural habitats. Fischer et al. (2011) also confirmed the positive impact of organic farming on small mammals, where arable land in the country makes up 80%.

Using redundancy analysis (RDA, SD = 2) we determined the relationship of species to environmental variables (soil temperature, moisture and pH). The variability of taxa was 15.3% on the first ordination axis and 21.8% on the second cumulative axis. Due to the influence of environmental variables, the variability increased to 69.8% (first ordination axis) and on the second cumulative axis, it increased to 99.5%. We found a statistically significant influence on the spatial structure of Small Mammals in soil temperature ($p = 0.0064$) and moisture ($p = 0.0476$). We confirmed the insignificant effect of pH

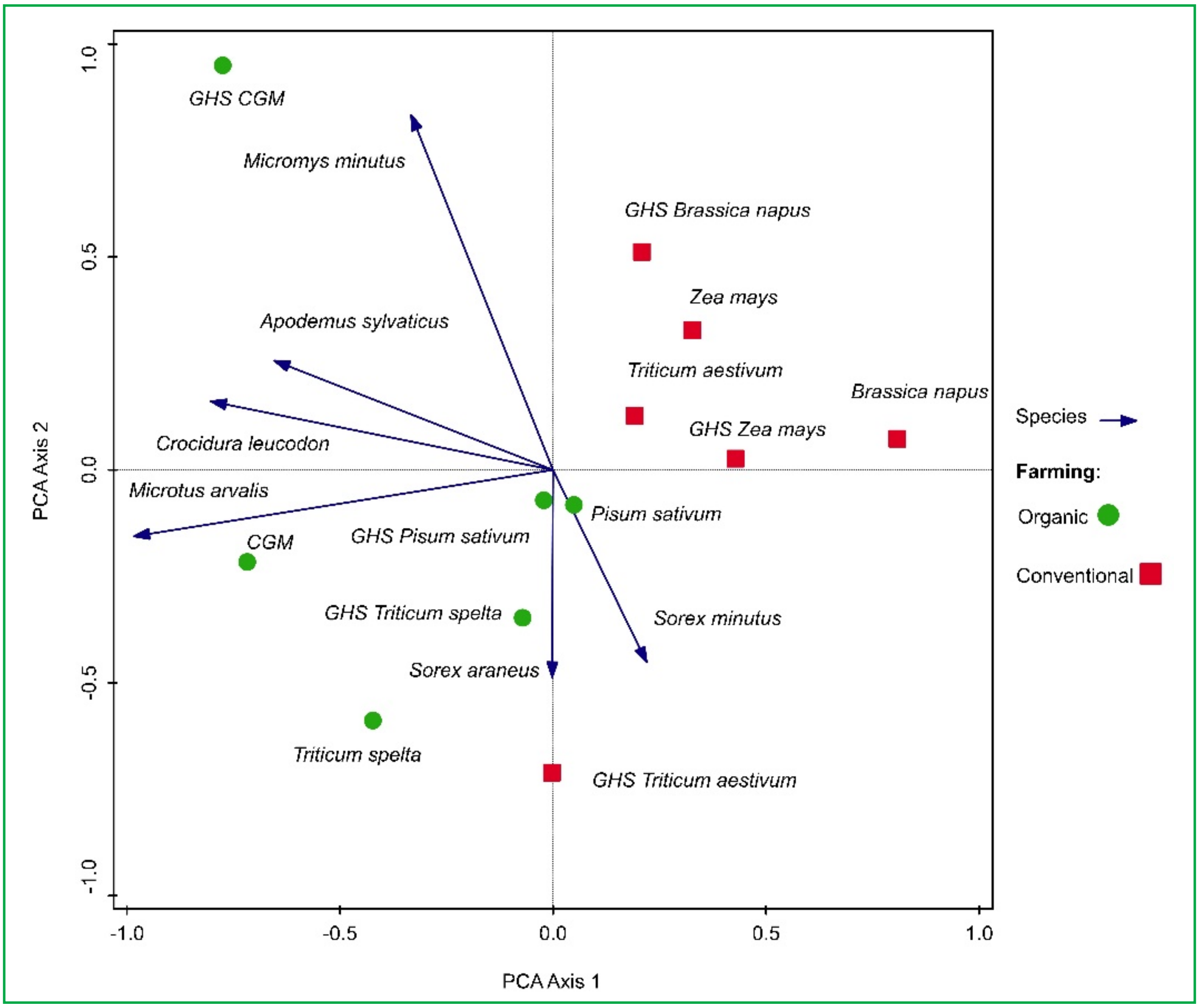


**Figure 2** PCA analysis of species linkage to crops and their grass-herb strip

($p$ = 0.42). On the ordination graph, we can see that soil temperature had the greatest effect on these species: *Apodemus sylvaticus*, *Microtus arvalis*, *Micromys minutus*, *Crocidura leucodon* and *Sorex araneus*. Moisture had the greatest influence on *Sorex minutus* (Figure 3). Small Mammals form a component of the soil fauna, due to the species specification they react to stress, therefore they are suitable for research on the disturbance of agroecosystems. They contribute to ecological stability in an intensively used agrarian landscape, they know how to adapt to the environment and react to stress due to changes in environmental variables such as pH, humidity and soil temperature. Pesticides and fertilizers also have an effect on their spatial dispersion (Michel et al., 2006; Simone et al., 2010).

The rarefaction analysis showed that the highest species richness of Small Mammals was within organic farming. With the same number of individuals, the diversity of Small Mammals did not change. The predicted number of species in organic farming is 7 (currently = 6) and 6 in Conventional farming (currently = 5) (Figure 4). Fischer and Schröder (2014), Baldi and Paruelo (2008) found that Small Mammals have higher abundance and species diversity in response to local and landscape effects in conventional agrarian landscape areas and ecological fields in simple landscapes. Alain et al. (2006) confirmed that the agrarian landscape supports the colonisation of fields by Small Mammals, thereby participating in habitat connectivity.

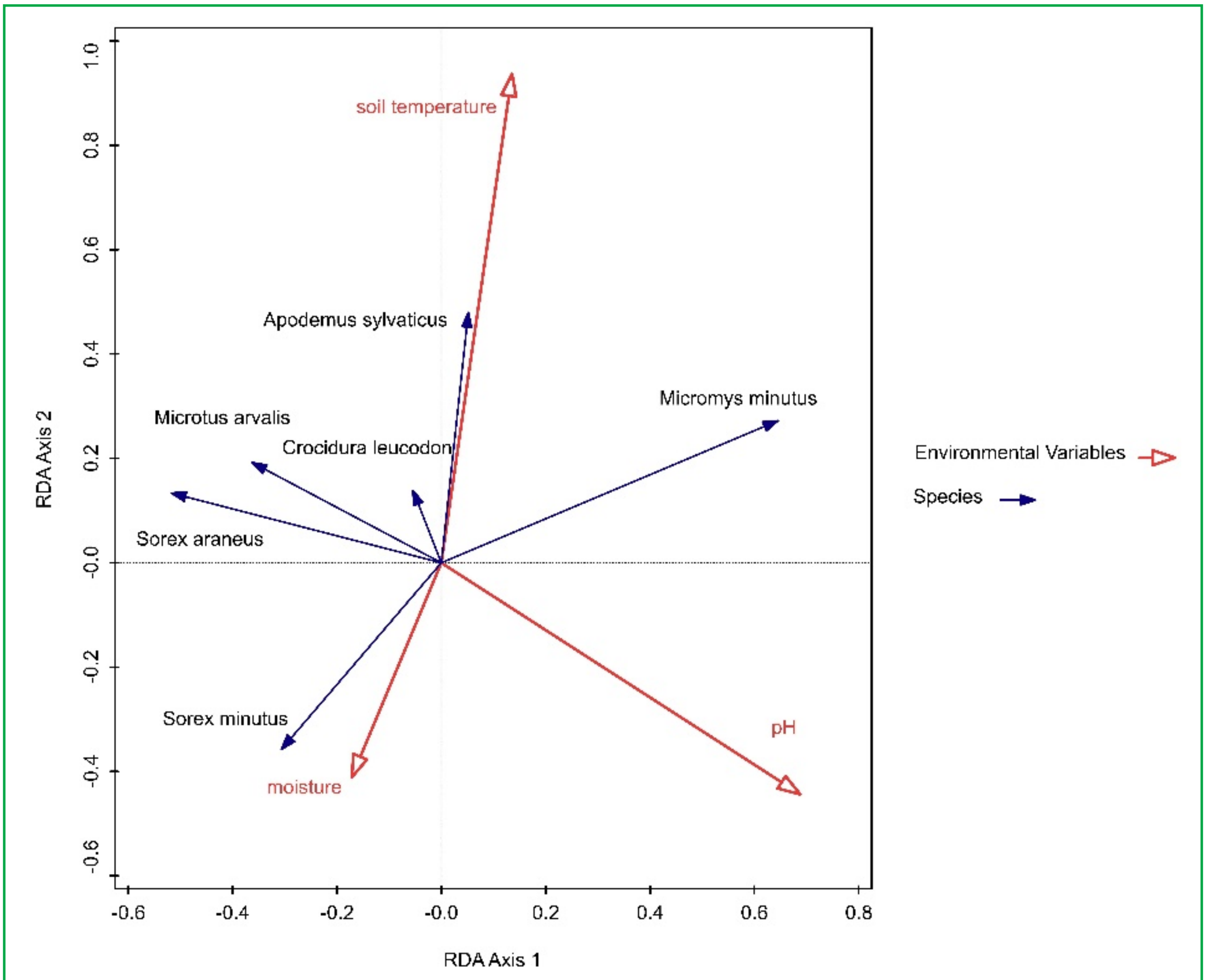


**Figure 3** RDA analysis of species and environmental variables

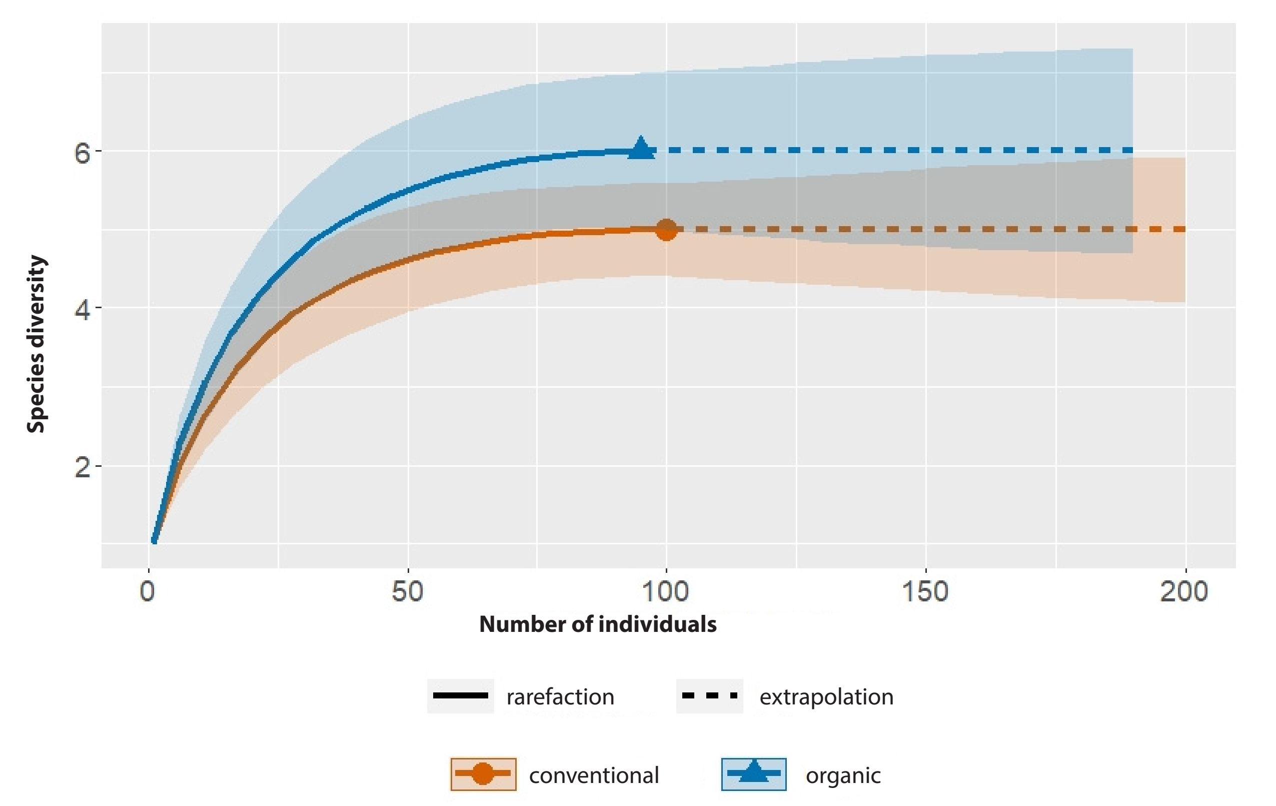


**Figure 4** Individual-based rarefaction (peripheral lines) and extrapolation curve (medium lines) of total species richness of Small Mammals

## 4 Conclusions

From the results of our research, we found new information about the spatial dispersion of small mammals under conditions of organic (*Pisum sativum*, *Triticum spelta* and Clover grass mix) and conventional (*Zea mays*, *Triticum aestivum* and *Brassica napus*) management. Using PCA analysis, we found the preference of small mammals for crops that were grown in an organic farming. RDA analysis confirmed the significant influence of temperature ($p = 0.0064$) and humidity ($p = 0.0476$) on the spatial dispersion of small mammals. Using the rarefaction curves, we recorded the greatest richness of species in organic management. Organic farming had a more positive effect on the spatial dispersion of small mammal species, which play an important role in agroecosystems, either as helpers in maintaining soil moisture and part of biomass, or as pests of crops.

### Acknowledgments

This research was supported by the grant KEGA No. 037SPU-4/2024 Data integrity in biological and ecological databases.

## References

Alain, B., Gilles, P., & Yannick, D. (2006). Factors driving small rodents assemblages from field boundaries in agricultural landscapes of western France. *Landscape Ecology*, 21(3), 449–461. https://doi.org/10.1007/s10980-005-4118-6

Baláž, I., Tulis, F., Veselovský, T., Klimant, F., & Augustiničová, G. (2013). *Rodents and insectivores of Slovakia* (in Slovak). Nitra, UKF.

Balčiauskas, L., Balčiauskienė, L., & Stirké, V. (2019). Mow the grass at the mouse's peril: Diversity of small mammals in commercial fruit farms. *Animals*, 9(6), 1–17. https://doi.org/10.3390/ani9060334

Baldi, G., & Paruelo, J.M. (2008). Land-use and land cover dynamics in South American temperate grasslands. *Ecology and Society*, 13(2),1–17. https://doi.org/10.5751/ES-02481-130206

Bashlykova L.A., & Korolev A.N. (2014). Records of common (*Microtus arvalis*) and Eastern European (*Microtus rossiaemeridionalis*) voles in the central part of the Komi Republic. *Zoologicheskii Zhurnal*, 93(11),1375–1380.

Batary, P., Báldi, A., Kleijn, D., & Tscharntke, T. (2011). Landscape-moderated biodiversity effects of agri-environmental management: a meta-analysis. *Proceedings of the Royal Society B*, 278(1713), 1894–902. https://doi.org/10.1098/rspb.2010.1923

Benedek, A., & Sîrbu, L. (2018). Responses of small mammal communities to environment and agriculture in a rural mosaic landscape. *Mammalian Biology*, 90, 55–65. https://doi.org/10.1016/j.mambio.2018.02.008

Bengtsson, J. Ahnstrom, J., & Christin Weibull, A. (2005). The effects of organic agriculture on biodiversity and abundance: a meta-analysis. *Journal of Applied Ecology*, 42(2), 261–269.
https://doi.org/10.1111/j.1365-2664.2005.01005.x

Briones, M.J.I., & Schmidt, O. (2017). Conventional Tillage Decreases the Abundance and Biomass of Earthworms and Alters Their Community Structure in a Global Meta-Analysis. *Global Change Biology*, 23(10), 4396–4419.
https://doi.org/10.1111/gcb.13744

Fischer, C., Thies, C., & Tscharntke, T. (2011). Small mammals in agricultural landscapes: opposing responses to farming practices and landscape complexity. *Biological Conservation*, 144(3),1130–1136.
https://doi.org/doi.org/10.1016/j.biocon.2010.12.032

Fischer, C., & Schröder, B. (2014). Predicting spatial and temporal habitat use of rodents in a highly intensive agricultural area. *Agriculture Ecosystems & Environment*, 189, 145–153.
https://doi.org/10.1016/j.agee.2014.03.039

Crowder, D.W., Northfield, D.T., Strand, R. M., & Snyder, E. W. (2010). Organic agriculture promotes evenness and natural pest control. *Nature*, 466(7302),109–112.
https://doi.org/10.1038/nature09183

Gabriel, D., Sait, M S., Kunin E.W., & Benton, G.T. (2013). Food production vs. biodiversity: comparing organic and conventional agriculture. *Journal of Applied Ecology*, 50, 355–364. https://doi.org/10.1111/1365-2664.12035

Gomez, M. D., Goijman, P. A., Coda, J., Serafini, V., & Priotto, J. (2018). Small mammal responses to farming practices in Central Argentinian agroecosystems: The use of hierarchical occupancy models. *Austral Ecology*, 43(7), 828–838.
https://doi.org/10.1111/aec.12625

Jurišič, A., Kranik, N., Ivanovič, I., Vukovič, S., & Potkonjak, A. (2021). Rodents and their control in orchards. *Biljni Lekar*, 49(5), 613-625. https://doi.org/10.5937/BiljLek2105613J

Coda, J., Gomez, D.M., & Steinmann, R.A., & Priotto, W. J. (2015). Small mammals in farmlands of Argentina: Responses to organic and conventional farming. *Agriculture, Ecosystems & Environment*, 211, 17–23.
https://doi.org/10.1016/j.agee.2015.05.007

Khlyap L.A., & Warshavsky A.A. (2010). Synanthropic and agrophilic rodents as invasive alien mammals. *Russian Journal of Biological Invasions*, 1(4), 301–312.
https://doi.org/10.1134/S2075111710040089

Malygin V.M. Baskevich, I.M., & Khlyap, L. (2020). Invasions of the common vole sibling species. *Russian Journal of Biological Invasions*, 11(1), 47–65.
https://doi.org/10.1134/S2075111720010087

Martínez, J.J, Millien, V., Simone, I., & Priotto, W.J. (2014). Ecological preference between generalist and specialist rodents: Spatial and environmental correlates of phenotypic variation. *Biological Journal of the Linnean Society*, 112(1), 180–203. https://doi.org/10.1111/bij.12268

Michel, N., Bruel, F., & Butet, A. (2006). How does landscape use influence small mammal diversity, abundance and biomass in hedgerow networks of farming landscapes? *Acta Oecologica*, 30(1),11–20. https://doi.org/10.1016/j.actao.2005.12.006

Montgomery, D.R. (2007). Soil erosion and agricultural sustainability. *Proceedings of National Academy of Sciences*. 104(33), 13268–13272.
https://doi.org/10.1073/pnas.061150810

R Version 4.1.3. (2020) *The R Foundation for Statistical Computing*: Vienna, Austria.

Sharma, S. (2011). Assessment of soil quality using microarthropod communities under different land system: A case study in the mid-hills of central Nepal. *Journal of Life Sciences*, 5(1), 66–73.

Simão, F.C.P., Carretero, A.M., & Amaral, A.J.M (2015). Composition and seasonal variation of epigeic arthropods in field margins of NW Portugal. *Turkish Journal of Zoology*, 39(3), 404–411. https://doi.org/10.3906/zoo-1401-69

Simone, I. Cagnacci, F., Provensal, C.M., Polop, J. (2010). Environmental determinants of the small mammal assemblage in an agroecosystem of central Argentina: the role of *Calomys musculinus*. *Mammalian Biology*, 75, 496–509.
https://doi.org/10.1016/j.mambio.2009.12.002

Stirkė, V., Balciauskas, L., & Balčiauskiené, L. (2022). Spatiotemporal variation of small mammal communities in commercial orchards across the small country. *Agriculture*, 12(5), 1–12. https://doi.org/10.3390/agriculture12050632

Ter Braak, C. J. F., & Šmilauer, P., (2012). *Canoco reference manual and user's guide: software for ordination*, vers. 5.0. Microcomputer Power, Ithaca, New York, USA.

Tscharntke, T., Klein, A., & Kruess, A. (2005) Landscape perspectives on agricultural Intensification and biodiversity – ecosystem service management. *Ecology Letters*, 8(8), 857–874.
https://doi.org/10.1111/j.1461-0248.2005.00782.x

Tscharntke, T., Clough, Y., Wanger, C.T., Jackson, E.L., Motzke, N.K.I., Perfecto, I., Vandermeer, J., & Whitbread, M.A. (2012). Global food security, biodiversity conservation and the future of agricultural intensification. *Biological Conservation*, 151(1), 53–59. https://doi.org/10.1016/j.biocon.2012.01.068

Tschumi, M., Ekroos, J., Hjort, K.C., Smith, G.H., & Brikhofer, K. (2018). Rodents, not birds, dominate predation-related ecosystem services and disservices in vertebrate communities of agricultural landscapes. *Oecologia*, 188(3), 863–873.
https://doi.org/10.1007/s00442-018-4242-z