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Changes in the Occurrence of Uncommon Species of Small Terrestrial Mammals (Eulipotyphla, Rodentia) in the Czech Republic

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Abstract

The paper summarizes recent observations of uncommon small terrestrial mammals (Eulipotyphla, Rodentia) in the Czech Republic and compares them with known ranges. In total, 5038 records of 13 species (*Apodemus agrarius*, *Apodemus uralensis*, *Arvicola amphibius*, *Crocidura leucodon*, *Crocidura suaveolens*, *Glis glis*, *Micromys minutus*, *Microtus subterraneus*, *Muscardinus avellanarius*, *Neomys fodiens*, *Neomys milleri*, *Sicista betulina*, and *Sorex alpinus*) were included. A database was created, including at least date, location, species, and observer for each record. For each species, a list of quadrats (KFME) with confirmed occurrence, along with selected records of the species in a given quadrat (oldest and youngest record, lowest and highest elevation), is included. These data were then compared with existing knowledge. The results show range expansion of thermophilic, steppe, and agricultural landscape species such as *Apodemus agrarius*, *Apodemus uralensis* and *Crocidura leucodon* into areas previously uninhabited by them. On the contrary, *Sorex alpinus*, one of the most typical mountain species, has not been observed in the southernmost part of its former range for the last 15 years. This study highlights the importance of monitoring the changes in the abundance of all species. These findings are important not only for managing and protecting biodiversity, but also for understanding the impacts of environmental change.

Keywords: *Apodemus agrarius*; Central Europe; *Crocidura leucodon*; *Sicista betulina*; *Sorex alpinus*

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1. Introduction

1.1. Small Terrestrial Mammals

Small terrestrial mammals (Rodentia and Eulipotyphla; tentatively 'smaller than a rabbit') play a key role in maintaining ecosystem functions [1]. They are essential for soil formation processes [2], plant dispersal, including woody plants [3], and insect population regulation [4], and they serve as important food sources for predators [5]. Because of their relatively low mobility and close association with environmental conditions, small terrestrial mammals are good indicators of environmental state and change [6]. Most attention is paid to the more numerous species of rodents and insectivores, such as *Apodemus flavicollis*,

Microtus arvalis, or *Talpa europaea*, as they often come into direct conflict with human interests and are easier to detect than uncommon species [7]. This facilitates their study and leads to a better understanding of their ecology, distribution and population trends [8].

1.2. Uncommon Species of Small Terrestrial Mammals

Uncommon species are typically either truly rare or infrequently recorded due to low detectability. Therefore, they are often overlooked. However, their ecological role may be much more important than their abundance or biomass would suggest [9]. These species play a key role in maintaining biodiversity not only among mammals but also in entire ecological networks. They contribute to the dispersal of seeds and spores and influence the spread of often specific microorganisms, including pathogens and zoonotic diseases [1,10–13]. However, monitoring these species is challenging, and available data are often random and disparate, complicating an analysis [8]. Therefore, detailed knowledge of their ecological requirements, preferred habitats, elevational and microhabitat limits, seasonal activity patterns, or even distribution dynamics is often lacking [14]. Nevertheless, this information is valuable, especially in the context of current changes in the landscape caused by human activities, climate change and the introduction of non-native species [15]. The term uncommon species does not refer to any official or standardized category; it is used to denote species that are rarely recorded or little known (the reasons for including specific species are listed in Table 1).

1.3. Mammals in the Czech Republic

At least 90 wild mammal species have been documented in the Czech Republic in recent years [16–18]. The spectrum of mammal species has changed quite substantially because of human activity in the Czech Republic. In the case of small mammals, the situation is quite different. Although introduced species can also be found among small mammals, they are usually strictly synanthropic and are rarely found outside human settlements (*Rattus rattus*, *Rattus norvegicus*, *Mus musculus*) [19]. The species spectrum of small mammals is therefore basically stable in the Czech Republic. However, this does not mean that the distribution and abundance of these taxa have not changed. The importance of many species has undergone a fundamental change that initially escaped attention. Some of the formerly important pests have become endangered within a few decades (e.g., *Cricetus cricetus*, *Spermophilus citellus*). In many others, not only abundance but also their known ranges have changed substantially, e.g., *Apodemus agrarius*, *Apodemus uralensis*, *Crocidura* spp. [17,18,20]. Despite relatively intensive attention paid to small mammals in the Czech Republic, we unfortunately know much less about most of these species than about larger mammals because they live inconspicuously, and it is relatively difficult to determine some species. This applies to uncommon species even more so. Closer monitoring of the mentioned changes and understanding their causes can have a major impact in preventing economic damage and protecting biodiversity.

1.4. Mammal Monitoring in the Czech Republic

Despite the absence of a systematic nationwide monitoring scheme for small terrestrial mammals in the Czech Republic, knowledge of their distribution has progressively improved. This advancement is primarily driven by increased expertise and the integration of modern technologies that facilitate both data collection and sharing [8]. Historically, records of species occurrence were highly individual and depended on the methodology and diligence of the recorder [21]. A shift from point records to range-based mapping occurred during the 20th century, with the Czech mammalogical community adopting the phytosociological mapping framework known as KFME (Kartierung der Flora Mitteleuropas; [22]). This grid divides the central European region into quadrats (“squares” or

more precisely quadrilateral grid cells) of 10 min of longitude × 6 min of latitude (≈cca 12 km × 11 km in Central European latitudes). Each basic cell is coded with a four-digit number: the first two digits indicating the row (north→south) and the next two digits the column (west→east). Within this system, the Czech territory is divided into 679 quadrats, of which 628 fall predominantly (>50%) within national borders (see Figures 1–13). Since the 1970s, this method has substantially contributed to monitoring species distribution ranges.

The development of mobile GIS tools and the increasing availability of remote sensing methods after 2000 further accelerated the evolution of monitoring strategies. This technological progress facilitated the emergence of centralized online databases that also integrate historical data. In the Czech Republic, two principal platforms for recording small mammal occurrences are BioLib (established in 1999; https://biolib.cz, accessed on 28 August 2024) and the Species Occurrence Database (NDOP hereinafter; launched in 2008; https://portal23.nature.cz/nd/find.php, accessed on 28 August 2024).

Table 1. Uncommon small terrestrial mammals of the Czech Republic– taxonomic and conservation status and main reasons for inclusion. Only species for which authors have relevant new data were included in subsequent analyses (these species are marked in **bold** in the table).

Species	Order	IUCN Status *	Council Directive 92/43/EEC Status **	Decree No. 395/1992 Coll. Status ***	Red List of Mammals of the Czech Republic *	Main Reason for Inclusion
Apodemus agrarius	**Rodentia**	**LC**	**-**	**-**	**LC**	**Occurrence only in part of the Czech Republic**
Apodemus uralensis	**Rodentia**	**LC**	**-**	**-**	**LC**	**Occurrence only in part of the Czech Republic**
Arvicola amphibius	**Rodentia**	**LC**	**-**	**-**	**LC**	**Data deficient**
Cricetus cricetus	Rodentia	CR	HD IV	2	LC	Occurrence only in part of the Czech Republic
Crocidura leucodon	**Eulipotyphla**	**LC**	**-**	**3**	**LC**	**Occurrence only in part of the Czech Republic**
Crocidura russula	Eulipotyphla	LC	-	-	-	A new species for the Czech Republic; data deficient
Crocidura suaveolens	**Eulipotyphla**	**LC**	**-**	**-**	**LC**	**Data deficient**
Dryomys nitedula	Rodentia	LC	HD IV	2	LC	Occurrence only in part of the Czech Republic
Eliomys quercinus	Rodentia	VU	-	1	CR	Protected on multiple levels
Glis glis	**Rodentia**	**LC**	**-**	**3**	**DD**	**Data deficient; protected on national level**
Micromys minutus	**Rodentia**	**LC**	**-**	**-**	**LC**	**Data deficient**
Microtus subterraneus	**Rodentia**	**LC**	**-**	**-**	**LC**	**Data deficient**
Muscardinus avellanarius	**Rodentia**	**LC**	**HD IV**	**2**	**LC**	**Protected on multiple levels**
Neomys milleri	**Eulipotyphla**	**LC**	**-**	**-**	**LC**	**Data deficient**

Table 1. *Cont.*

Species	Order	IUCN Status *	Council Directive 92/43/EEC Status **	Decree No. 395/1992 Coll. Status ***	Red List of Mammals of the Czech Republic *	Main Reason for Inclusion
Neomys fodiens	**Eulipotyphla**	**LC**	**-**	**-**	**LC**	**Data deficient**
Sicista betulina	**Rodentia**	**LC**	**HD IV**	**2**	**VU**	**Protected on multiple levels**
Sorex alpinus	**Eulipotyphla**	**NT**	**-**	**2**	**VU**	**Protected on multiple levels**
Spermophilus citellus	Rodentia	EN	HD II + HD IV	1	CR	Protected on multiple levels

Legend to Table 1: *—LC—least concern; NT—near threatened; DD—data deficient; VU—vulnerable; EN—endangered; CR—critically endangered; **—HD II—included in Annex II; HD IV—included in Annex IV; ***—1—critically endangered species; 2—highly endangered species; 3—endangered species.

1.4.1. BioLib.cz

BioLib is a user-friendly, citizen-science-based online encyclopedia that provides basic taxonomic information, photographs, and general data on individual taxa, including small terrestrial mammals. Data can be uploaded and edited by anyone, but are not peer-reviewed. As a result, data are sometimes incomplete (lacking exact date, locality, finders, etc.). Although freely available, BioLib is more suited for a basic overview than as a reliable basis for research or government decision-making.

1.4.2. NDOP

NDOP is an official system operated on behalf of the Ministry of the Environment of the Czech Republic by the Nature Conservation Agency of the Czech Republic. NDOP collects historical and current data on biodiversity (occurrence records of organisms). Currently (October 2025), NDOP contains over 39 million published records. Any registered user can upload the records. In the interest of protecting organisms, NDOP allows us to postpone the publication of some observations (e.g., bird nesting or occurrence of attractive insects). Each record also indicates whether it has been validated by an expert (botanist, mycologist, zoologist, etc.), and therefore whether the record is reliable. NDOP is becoming a key tool used in research, nature conservation and state administration.

1.5. Aim of the Paper

Some species of small terrestrial mammals are observed in the Czech Republic only in tens or units of cases per year, or even only once every few years. Some (often the same) species do not occur throughout the territory; therefore, knowledge of them is very limited. Rare or random observations are of limited use in conventional data evaluation. They are often difficult or impossible to statistically evaluate due to methodological heterogeneity and stochasticity. Nevertheless, we believe that these data provide valuable insights into the distributional dynamics of rare taxa and their ecological requirements (e.g., habitat preferences, climatic limits, seasonal activity patterns) [14].

The aim of this paper is to collect as much unpublished but reliable evidence as possible on the occurrence of uncommon species of small terrestrial mammals in the Czech Republic, to compare it with the available knowledge, and to report any differences and changes.

2. Materials and Methods

The work proceeded in four main steps:

1 Setting criteria: identifying uncommon small terrestrial mammal species based on these criteria.
2 Creation of a database of reliable unpublished records from the territory of the Czech Republic.
3 Comparison of the created database with published reliable data.
4 Interpretation of findings for individual species.

We focus on species of rodents (Rodentia) and insectivores (Eulipotyphla) that are not widespread throughout the Czech Republic or species subject to special legislative protection. We have also included species with limited or, for various reasons, incomplete information about their distribution and frequency of occurrence. The list of species, including the main reason for their inclusion and protection level, is given in Table 1.

Data were collected in the Czech Republic between 1994 and 2024 using different sampling methods. Each included record was found or personally verified by one of the authors of this study, which ensures high credibility and reliability of the data obtained. Most records come from incidental non-targeted finds and observations of living or dead individuals, or from conclusive signs of residence (faeces and nests). Only a minority of records come from systematic monitoring or scientific research. Details of the research projects are provided at the end of the text in the "Funding" section. Unfortunately, it is therefore not possible to compare sampling effort or population dynamics of species from these data; they only provide evidence of the occurrence of a species in a particular place and time.

The elevation for each record was calculated in ArcGis Pro [23] based on its coordinates and the 'Extract Values to Points' function. The elevation is based on ArcČr 500 version 3.3 data [24], where the Digital Relief Model Generation 4 (DMR4G) was used to generate the data. The resulting database was compared with BioLib.cz, NDOP [25] and other expert literature. For the possibility of comparison with older data and literature, we also processed the new data in the KFME system [22]; each quadrat mentioned in the following text is in the sense of KFME.

The random nature of most records meant that it was not possible to determine the sampling effort or species abundance. However, accurate data on the time and place of discovery were available; therefore, the collected data were reduced according to a species-quadrat key. Only four key records were retained for each quadrat: the oldest record, the youngest record, the record from the highest elevation, and the record from the lowest elevation (note: where these key records overlapped, fewer records were kept).

The following were considered notable records:

1. The first record of a species in a given quadrat.
2. A record of a species in a quadrat after more than 10 years (the period of 10 years was chosen subjectively, but it is a period during which significant changes in abundance and distribution of small terrestrial mammals may have already occurred [26,27]).
3. A record from an elevation outside the typical elevation range of the species in the Czech Republic (Table 2).

These records are listed in Table 3; the attached maps were created on their basis.

3. Results

A total of 5038 records of 13 species of small terrestrial mammals (8 species of Rodentia and 5 species of Eulipotyphla) from the years 1994–2024 in the territory of the Czech Republic from a total of 65 different KFME quadrats in the total elevation range of 162–1238 m were included.

Basic information about the included species obtained from available sources is presented in Table 2. Table 3 summarizes notable records collected by the authors. For each species, a map is attached, allowing for the comparison of known and unpublished records of distribution (Figures 1–13).

Table 2. Basic information on 13 uncommon species of small terrestrial mammals.

Species	Preferred Habitats	Typical Elevation Range in CZ [19,20]	KFME Quadrats with Records in CZ [25]	Records in CZ [25]	Areal Trends in Central Europe
Apodemus agrarius	Agricultural landscape, shrubby ecotones [28]	~200–600 m	201	1167	Expansion north and west [29,30]
Apodemus uralensis	Lowland arable landscape [31]	~150–400 m	43	143	Disjunct but stable [31,32]
Arvicola amphibius	Freshwater riparian zones [33]	~200–800 m	482	1610	Stable [33,34]
Crocidura leucodon	Arable and pastureland [35]	~150–600 m	229	452	Expansion north [20,36]
Crocidura suaveolens	Synanthropic agricultural landscape [37]	~200–600 m	487	1502	Expansion north [18,38]
Glis glis	Old-growth deciduous forests [39]	~200–600 m	249	3789	Stable [40]
Micromys minutus	Monocotyledonous vegetation [41]	~200–600 m	480	1305	Stable [42]
Microtus subterraneus	Natural and seminatural grasslands [43]	~200–800 m	134	307	Stable [44]
Muscardinus avellanarius	Forests and shrublands [45,46]	~140–750 m	432	3804	Stable [47]
Neomys fodiens	Freshwater riparian zones [48]	~200–600 m	601	2256	Stable [20,49]
Neomys milleri	Freshwater riparian zones [49]	~200–700 m	458	1240	Stable [49]
Sicista betulina	Mountain forests [50]	~600–1000 m	46	188	Data deficient, fragmented [51]
Sorex alpinus	Mountain forests and grasslands [52]	~500–1200 m	135	626	Data deficient, fragmented [20,53]

Table 3. Overview of notable records for each species (first quadrat records, rediscoveries after >10 years, exceptional elevations). A quadrat refers to the KFME network.

Species	First Records		Rediscoveries After >10 Years)		Exceptional Elevations		
	Number of Quadrats	Quadrat Number	Number of Quadrats	Quadrat Number	Found Range (m)	Outside Typical Elevation Range in CZ	Record Elevations
Apodemus agrarius	1	6665	0	–	235–999	18 above	2× over 900 m; 2× over 700 m
Apodemus uralensis	1	6171	1	7065	184–470	1 above	over 400 m
Arvicola amphibius	2	5157; 5663	5	5852,5860, 5861, 5962, 5966	233–805	1 above	over 800 m
Crocidura leucodon	4	5347; 5744; 5764; 6766	1	6767	162–799	7 above	7× over 700 m
Crocidura suaveolens	1	5663	2	5860; 5962	190–947	7 above, 3 below	1× over 900 m; 3× over 700 m; 3× below 200 m
Glis glis	0	-	2	5057; 5361	463–1177	493 above	1× over 1000 m; 74× over 900 m; 219× over 800 m
Micromys minutus	4	5445; 5764; 5770; 6475	5	5662; 5844; 5860; 5966; 6766	162–870	18 above, 7 below	4× over 800 m; 9× over 700 m; 7× below 200 m
Microtus subterraneus	7	5770; 5845; 6475; 6766; 6851; 6962; 7065	2	5860; 6665	172–1200	29 above, 18 below	16× over 1100 m; 3× over 1000 m
Muscardinus avellanarius	3	5361; 5761; 5769	5	5260; 5359; 5360; 6171; 6472	237–1238	2253 above	2× over 1200 m; 16× over 1100 m; 54× over 1000 m
Neomys fodiens	0	-	7	5157; 5860; 5862; 5962; 6064; 6362; 6766	162–1238	41 above, 1 below	3× over 1200 m; 6× over 1000 m; 1× below 200 m
Neomys milleri	0	-	3	5962; 6475; 6962	302–940	15 above	3× over 900 m; 4× over 800 m
Sicista betulina	0	-	1	5768	605–1200	4 above	2× over 1100 m; 2× over 1000 m
Sorex alpinus	0	-	1	5663	516–1238	7 above	7× over 1200 m

Distribution maps of species are sorted alphabetically by their scientific names.

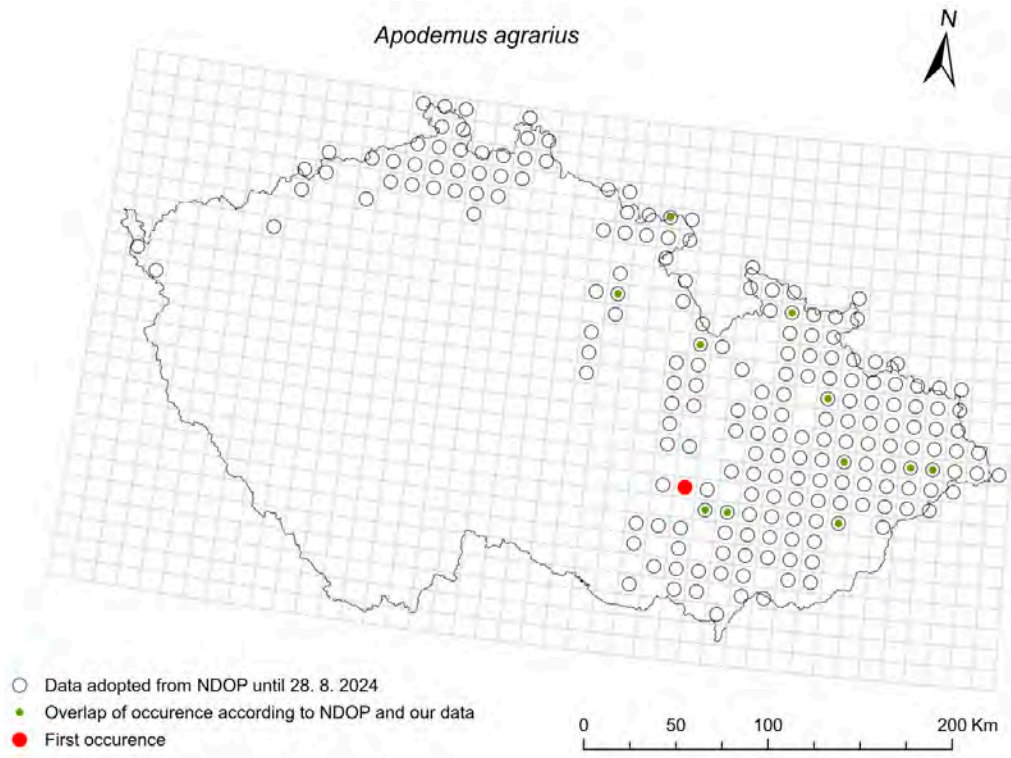

Figure 1. Distribution of *Apodemus agrarius* (Pallas, 1771), Striped Field Mouse.

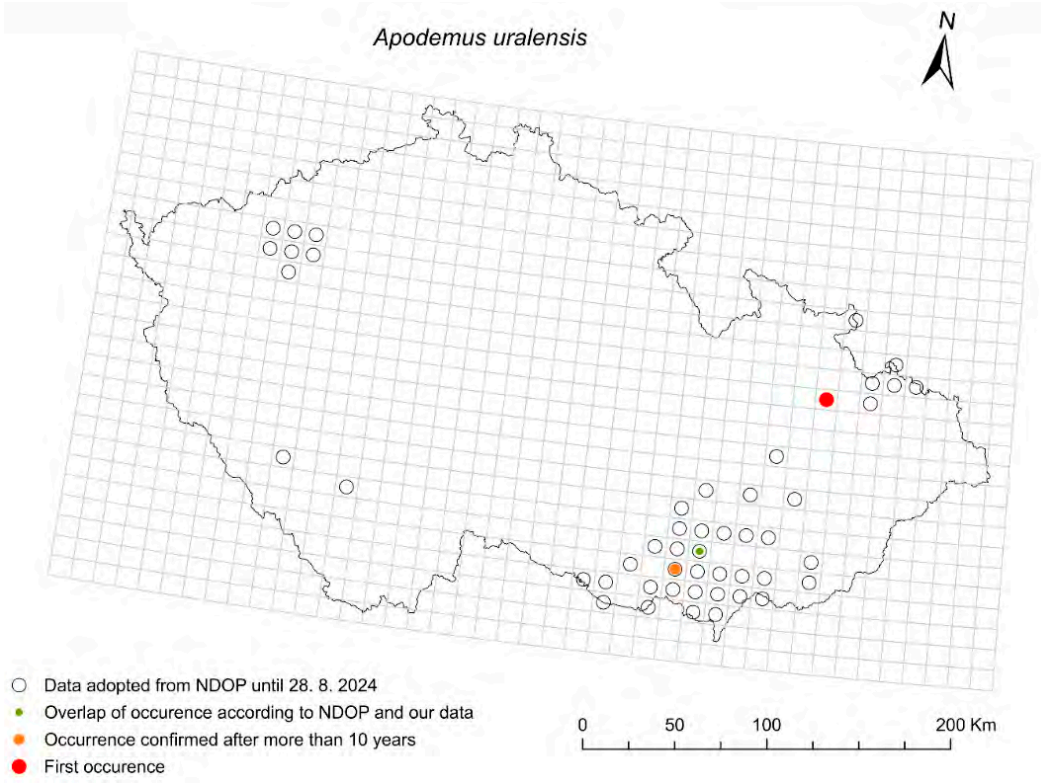

Figure 2. Distribution of *Apodemus uralensis* (Pallas, 1811) (syn. *A. microps* Kratochvíl et Rosický, 1952), Herb Field Mouse.

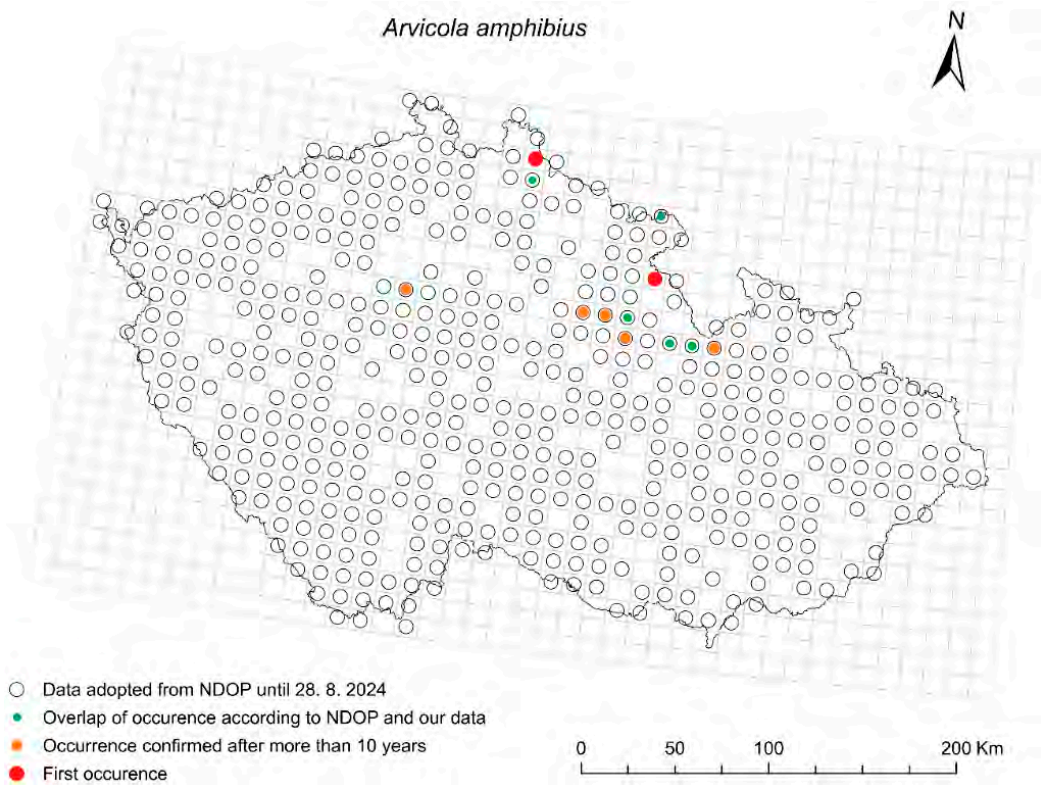

Figure 3. Distribution of *Arvicola amphibius* (Linnaeus, 1758), Eurasian Water Vole.

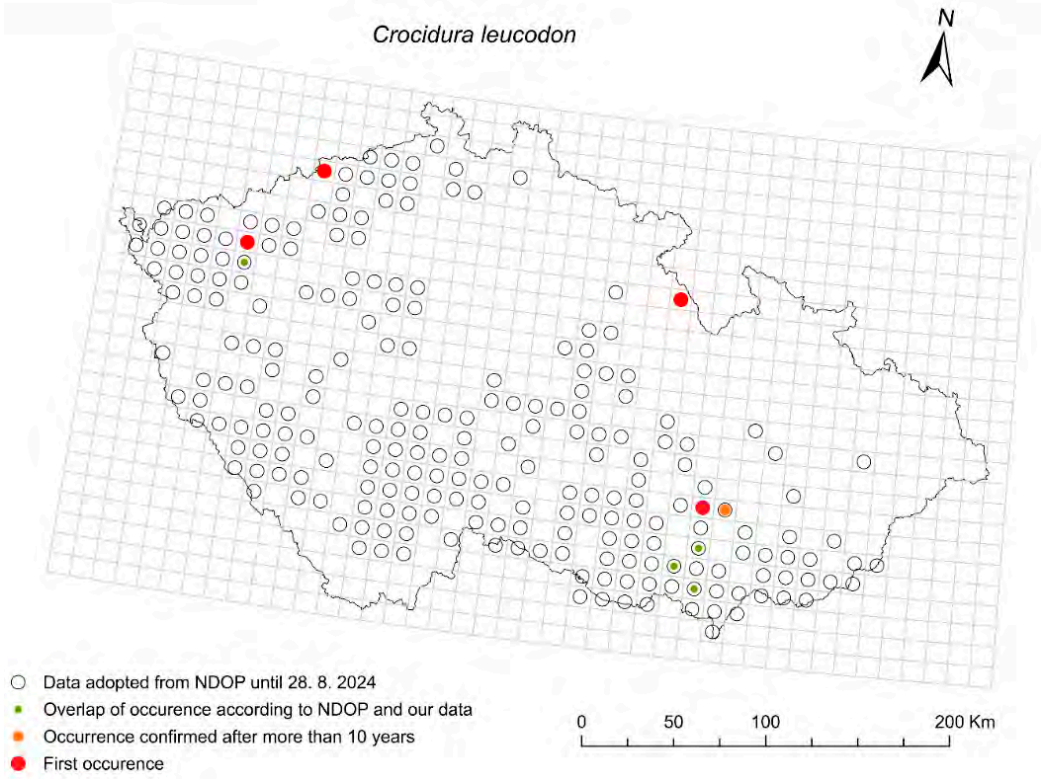

Figure 4. Distribution of *Crocidura leucodon* (Hermann, 1780), Bicolored White-toothed Shrew.

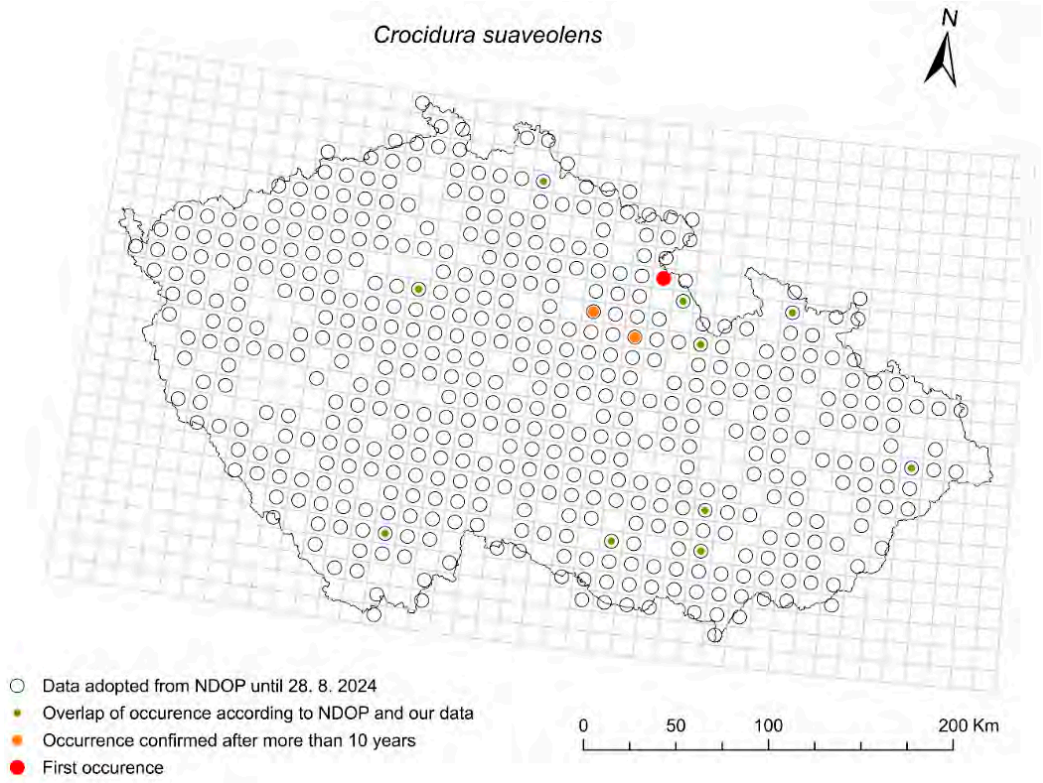

Figure 5. Distribution of *Crocidura suaveolens* (Pallas, 1811), Lesser White-toothed Shrew.

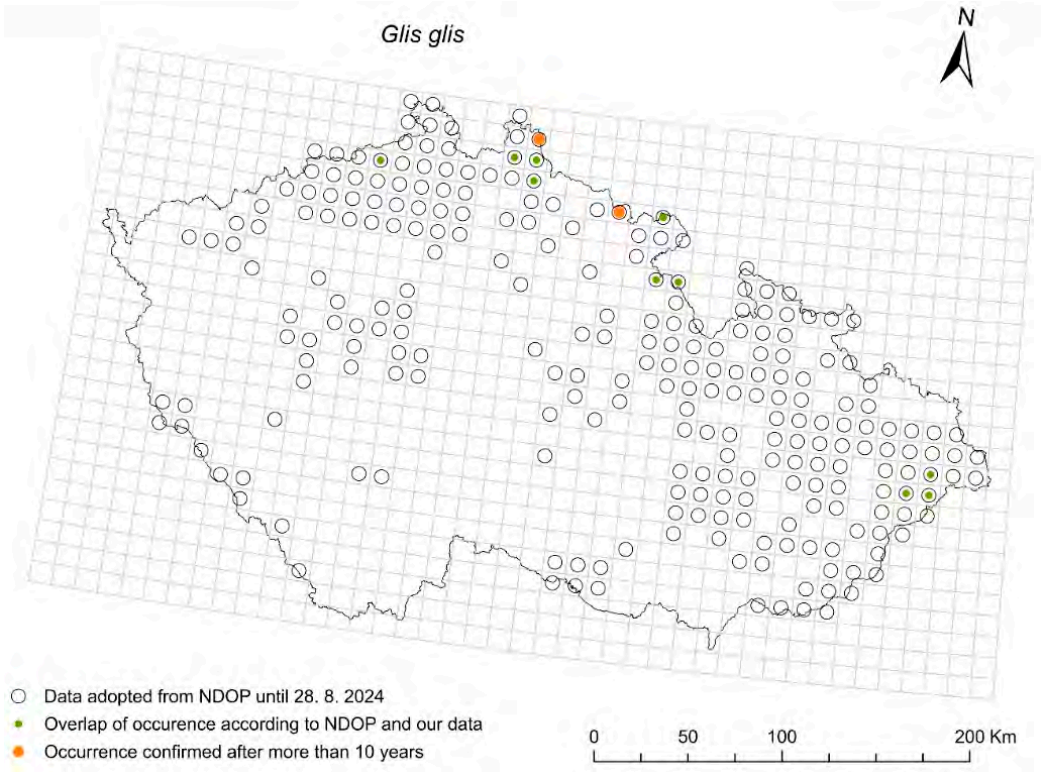

Figure 6. Distribution of *Glis glis* (Linnaeus, 1766), Edible Dormouse.

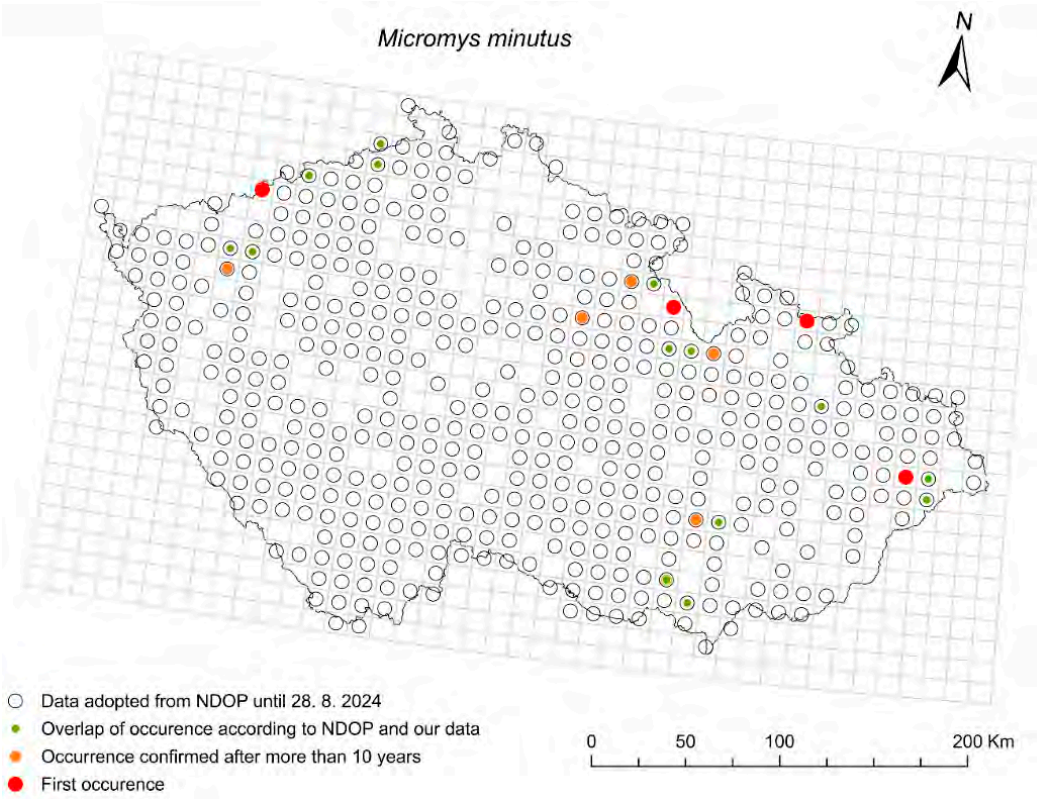

Figure 7. Distribution of *Micromys minutus* (Pallas, 1771), Eurasian Harvest Mouse.

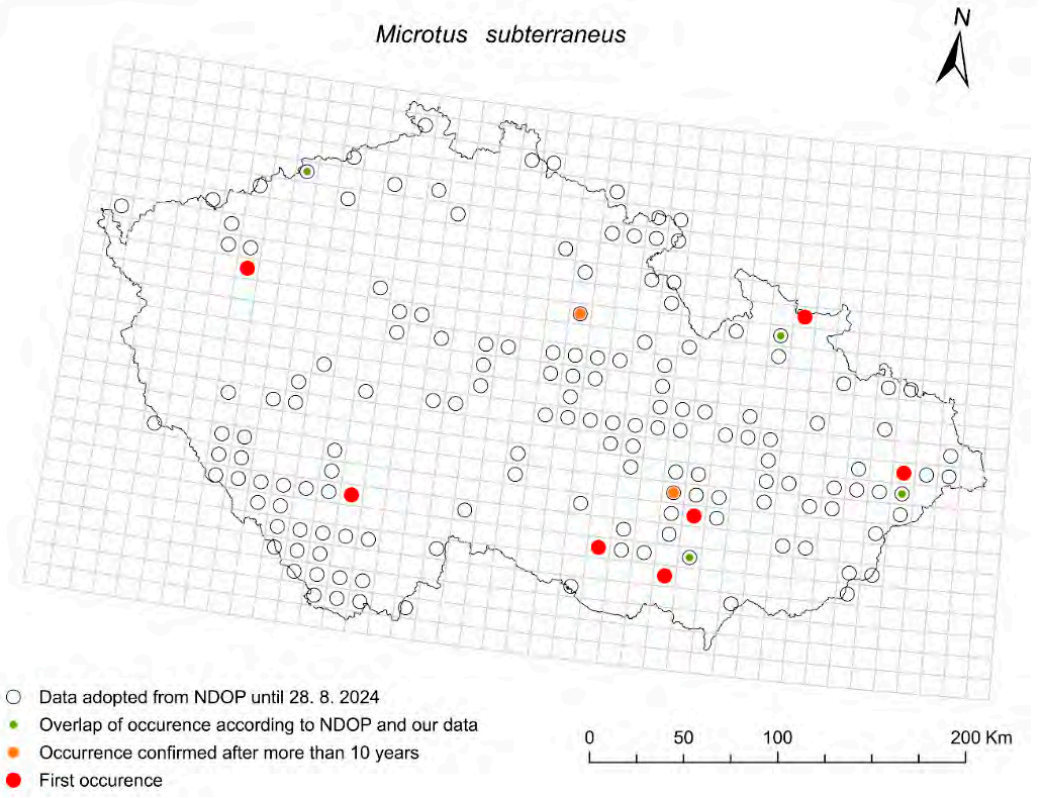

Figure 8. Distribution of *Microtus subterraneus* (de Sélys-Longchamps, 1836), European Pine Vole.

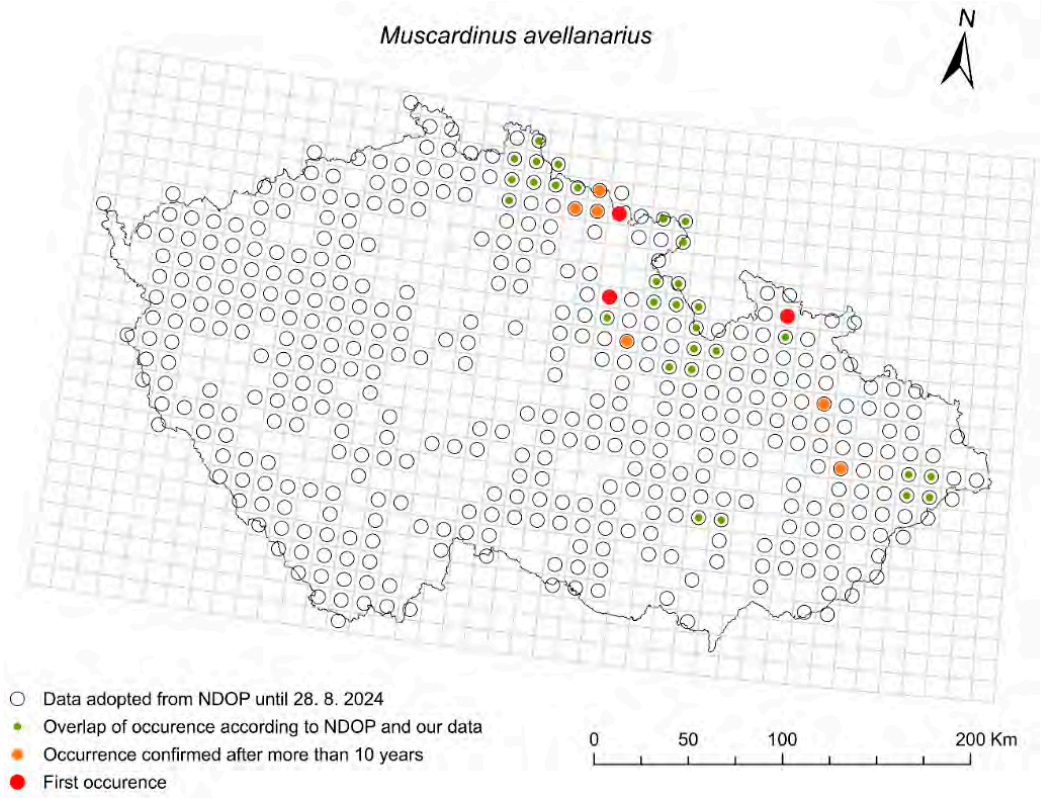

Figure 9. Distribution of *Muscardinus avellanarius* (Linnaeus, 1758), Hazel Dormouse.

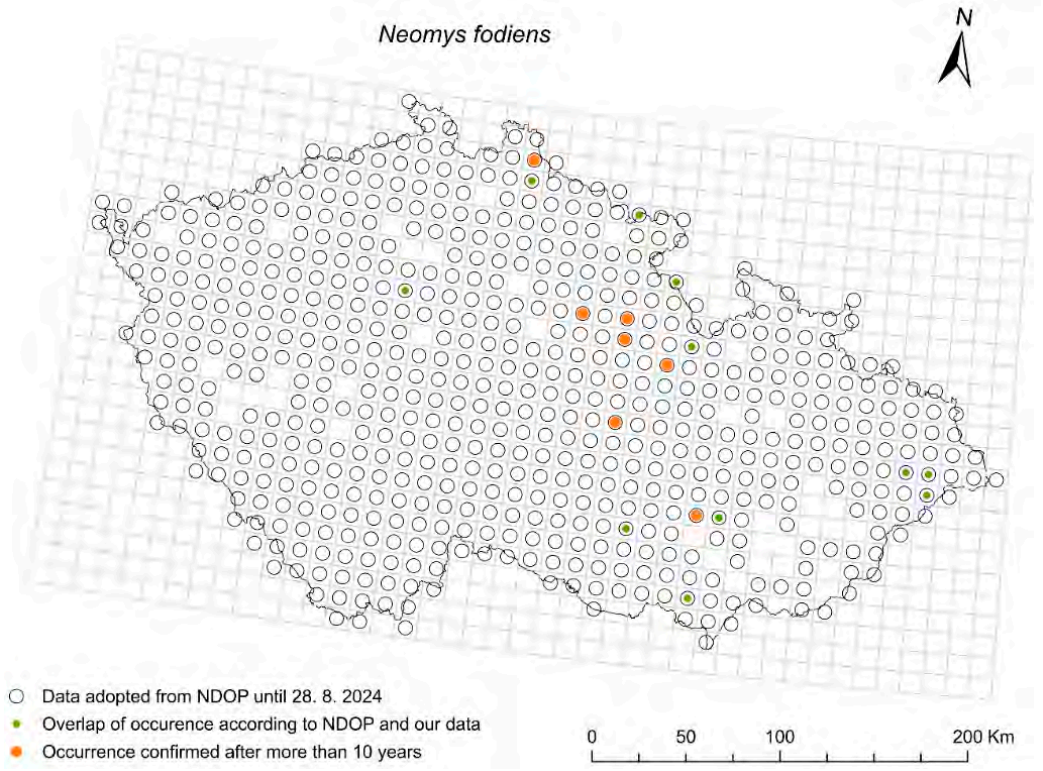

Figure 10. Distribution of *Neomys fodiens* (Pennant, 1771), Eurasian Water Shrew.

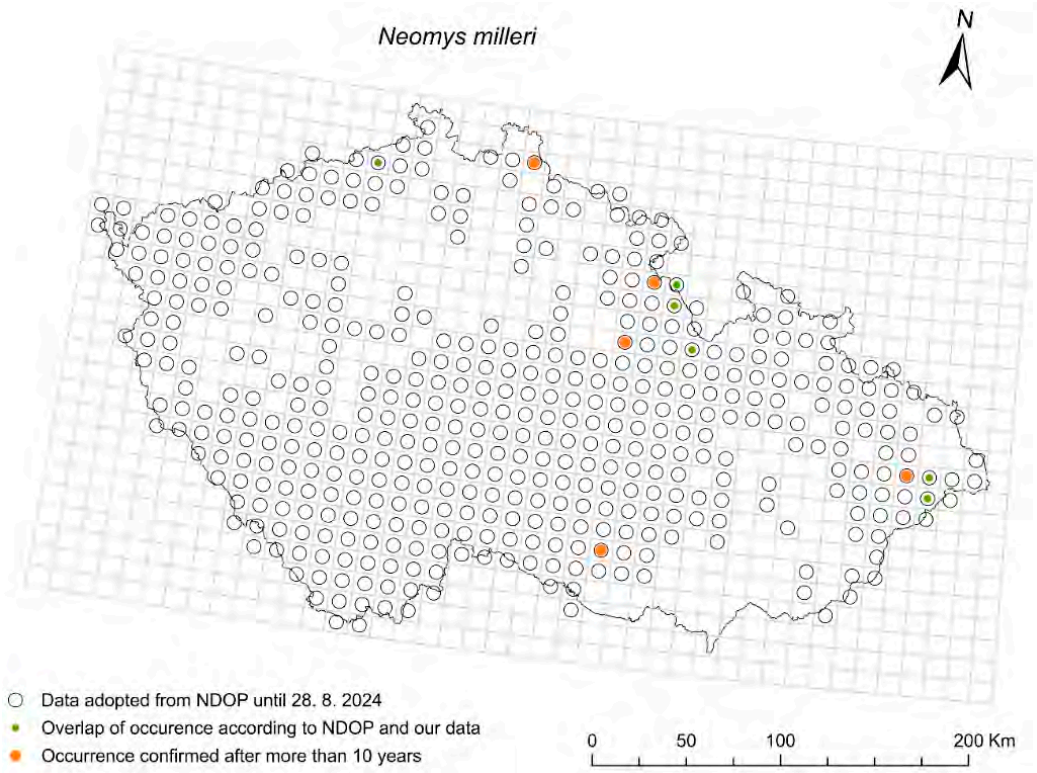

Figure 11. Distribution of *Neomys milleri* (Motaz, 1907, previously *Neomys anomalus* Cabrera, 1907), Miller's Water Shrew.

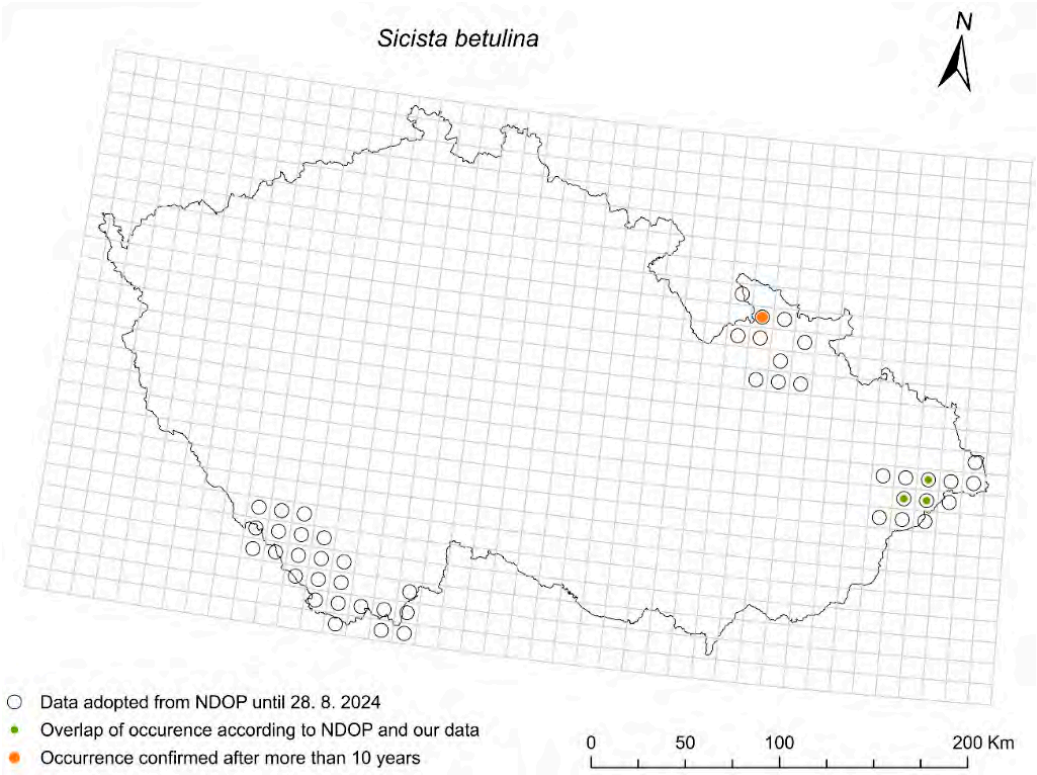

Figure 12. Distribution of *Sicista betulina* (Pallas, 1779), Northern Birch Mouse.

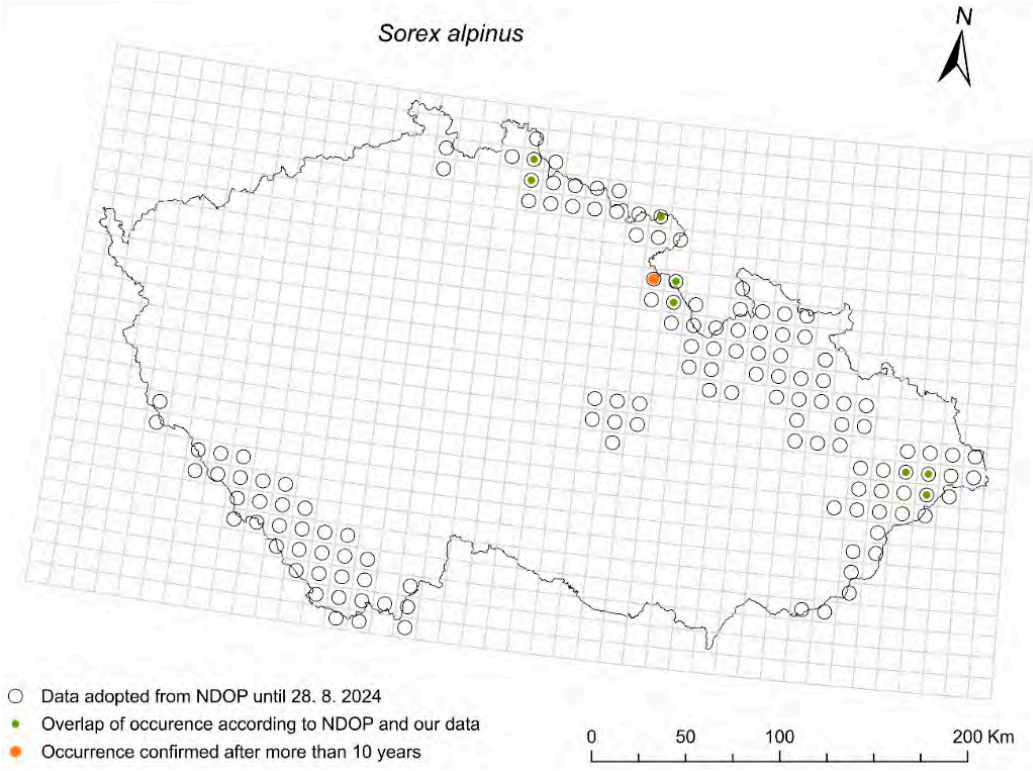

Figure 13. Distribution of *Sorex alpinus* (Schinz, 1837), Alpine Shrew.

4. Discussion

For all 13 species, one or more significant records concerning the location and time were found (the first record of the species in the quadrat or rediscovery after more than 10 years; see Table 3).

In total, 38 cases confirmed the presence of species in the quadrat after more than 10 years—sometimes after several decades. For example, *Glis glis* had not been documented in quadrat 5057 even after 132 years. In all these cases, however, it can be assumed with a high degree of probability that the species had persisted undetected due to low detectability or limited monitoring rather than actual absence.

Particularly relevant are the first records of the species in the quadrat; there are 23 confirmed new findings. By comparing these findings with the current distribution patterns of individual species, we can divide species into three groups:

(1) Widespread but under-recorded species

This group includes *Arvicola amphibius*, *Crocidura suaveolens*, *Glis glis*, *Micromys minutus*, *Microtus subterraneus*, *Muscardinus avellanarius*, *Neomys fodiens* and *Neomys milleri*. They are species most likely to be ubiquitous in Central Europe. Their distribution is generally even, but new records probably fill gaps where they were likely present all along. Factors such as difficulty of determination, inconspicuousness, low population densities, or specific habitat requirements (for example, preference of *Neomys fodiens* and *Neomys milleri* for an aquatic environment [54]) may explain their previous absence from the records.

(2) Rare mountain relict species

This group includes *Sicista betulina* and *Sorex alpinus*. These are species whose ranges cover only the colder parts of the Czech Republic at higher elevations and in colder, predominantly forested areas. Both mountain species were probably rediscovered in long-occupied but poorly monitored sites. The range of *Sicista betulina* appears stable. However, given the minimal number of records, these are likely to be persistent, isolated

relic populations. *Sorex alpinus* occurred in the Czech Republic in four separate regions: from the Lužické Mountains to the Nízký Jeseník Mountains, the Pošumaví region, the central part of the Bohemian-Moravian Highlands, and the Western Carpathians [20]. Over the past 15 years, it appears to have gradually disappeared from the southernmost parts of its range in the Czech Republic (e.g., south of the Šumava Mts., Bílé Karpaty Mts., Žďárské vrchy; see map in NDOP). Although these trends remain uncertain due to the sporadic nature of records, they may be early signals of areal contraction.

(3) Expanding species

The third group includes species *Apodemus agrarius*, *Apodemus uralensis*, and *Crocidura leucodon*. Their current known range does not cover the entire territory of the Czech Republic. Unlike the previous groups, this group shows a gradual spread into squares adjacent to the current range. In some cases, however, these species have also penetrated distant areas with significantly different geomorphology and climate.

In contrast to the previous one, this group not only exhibits a gradual spread into quadrats adjacent to the current range but also a sudden expansion into a very distant area. Moreover, this new area is significantly different in terms of geomorphology and climate compared to the current areas of occurrence.

In several cases, the findings exceed the previously known range of elevations with the occurrence of the species in the Czech Republic (Tables 2 and 3). However, only *Apodemus uralensis* found in quadrat 6171 at an elevation of 470 m significantly deviates from the range in the literature [19,20]. This finding represents both the first record for the site and the highest confirmed elevation for the species in the Czech Republic, although there are several other unvalidated records from the area (see https://www.biolib.cz; accessed on 28 August 2024). This species is typically associated with treeless, flat, dry lowlands dominated by arable land [17,31], so its upward shift may suggest a gradual expansion facilitated by changing land-use or climatic conditions. This may indicate the spread of *Apodemus uralensis* to higher elevations and the potential connection of its formerly disjunct populations in northern and southern Moravia (Figure 2).

Another example is *Crocidura leucodon*, recorded in Orlické Záhoří (quadrat 5764), at over 700 m a.s.l., which is one of the coldest places in the country [55]. This occurrence in an extremely cold area at high elevation is particularly remarkable, as the species is typically associated with warm, lowland habitats [21,35,56]. Its nearest known locality lies over 40 km away in the Hradec Králové lowlands [25]. The observation of multiple individuals strongly suggests the presence of a newly established local population. This suggests a sudden and discontinuous expansion, which is likely the result of ongoing ecological changes and possibly unintentional assisted migration. It will therefore be interesting to see whether this population will persist in the long term and whether it originates from the Czech Republic, Poland, or elsewhere.

The expansion of more thermophilic and steppe species to higher altitudes and, conversely, the retreat of mountain species fits into the context of ongoing climate change. Since the 1960s, average annual temperatures in most of the Czech Republic have risen by more than 2 °C [57]. Total annual precipitation has remained roughly the same, but its distribution throughout the year is less regular [58]. These changes trigger a cascade of other changes, such as shorter snow cover, longer growing seasons, and more frequent and intense droughts [59]. In the long term, Central Europe is experiencing warming and drying of the landscape that is above the global average [57]. These conditions should suit 'steppe' *Apodemus* mice more than mountain species.

Based on these results, it appears that the ranges of steppe and thermophilic species (*Apodemus agrarius*, *Apodemus uralensis* and *Crocidura leucodon*) are currently expanding in the Czech Republic. Whether mountain species are in decline, on the other hand, cannot

yet be determined with certainty. However, the absence of observations of *Sorex alpinus* in the southernmost areas of its former range over the past 15 years suggests this may be the case. Only repeated records and observations can prove whether this is a trend of species expansion or decline, or whether these are just isolated cases. Either scenario would mean that even one of the most stable components of fauna—small terrestrial mammals—is affected by environmental changes. In the context of climate and landscape change, the question is not whether, but how quickly and which taxa will be most affected.

5. Conclusions

Mammal monitoring in the Czech Republic is at a very good level. Nevertheless, we still lack basic information about uncommon species, such as changes in their distribution ranges and population dynamics, not to mention ecological, ethological or physiological details. Given the low population densities and often rather random nature of the records of the species included, it is difficult to determine whether current changes described reflect long-term trends or short-term fluctuations.

The data collected in this study aimed to fill this gap. It revealed significant updates in the distribution and elevation ranges of 13 small terrestrial mammal species in the Czech Republic. The data expands existing knowledge about new locations and the latest findings. Thermophilic, steppe, and agricultural landscape species such as *Apodemus agrarius*, *Apodemus uralensis* and *Crocidura leucodon* are expanding into previously uninhabited areas and to higher altitudes than previously observed. On the contrary, *Sorex alpinus*, one of the most typical mountain species, has not been observed in the southernmost part of its former range for 15 years. The changes observed in the occurrence of other species were not as significant.

Except for *Apodemus agrarius*, the ranges of the species included are considered stable in Central Europe. However, even outside the Czech Republic, these species are relatively rare. It is therefore possible that the shifts in range observed are also occurring throughout Central Europe.

The findings highlight the importance of long-term monitoring and more detailed studies, especially for species whose distributions appear to be moving. These results not only expand the known ranges of several species but also contribute to understanding the impacts of climate change and environmental modification on the biodiversity of small terrestrial mammals in Central Europe. Research should be expanded to include genetic studies and habitat assessments to better understand these changes and better target future conservation efforts.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/d17120815/s1, Table S1: Species key records within quadrats (oldest and most recent record, lowest and highest elevation).

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Abbreviations

The following abbreviations are used in this manuscript:

KFME	Kartierung der Flora Mitteleuropas; is a network mapping system for geographical mapping of plants and animals in Central Europe, which divides the territory into mapping fields measuring 10′ longitude and 6′ latitude.
NDOP	Species Occurrence Database by the Nature Conservation Agency of the Czech Republic

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