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An evaluation of two counting methods to establish rodent densities in crop fields

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Abstract: The common vole (*Microtus arvalis*) is the main pest in agricultural areas of Central Europe. It is particularly important to monitor its numbers during spring, and if high numbers are detected, some form of pest management should be considered. In the Czech Republic, the number of active burrows is monitored using the burrow index, BI, which allows estimation of the total number of rodents, saves time and is easy to use. We aimed to assess the relationship between the burrow index and the relative abundance of the rodent species examined by snap trapping in crop fields. Bayesian MCMC algorithms with a zero-inflation model were used for this analysis. The positive relationship between BI and vole abundance occurred in the total sample of all fields and in alfalfa, winter wheat and barley crop fields. A positive relationship between BI and the abundance of the wood mouse (*Apodemus sylvaticus*), the second most common pest in the area, was only confirmed in barley, and this relationship was negative in winter rape. The positive influence of the degree of weed cover on BI was confirmed in the total sample and in winter rape and alfalfa, but weed cover has a negative effect on BI in barley and winter wheat. In contrast, weed cover did not affect the relative abundance of both rodent species in any of the sampled crops. The presence of shrubs and forests around the fields reduced BI in the whole sample, especially in alfalfa. The relative abundance of the voles was not affected by the presence of shrubs and forests around the crop. Still, a positive influence was confirmed for the abundances of mice in the whole sample and alfalfa. BI can be a reliable indicator of vole abundance in crops with high densities, but it is not very accurate at low densities and in crop fields rarely used by voles, such as sunflower and maize.

Keywords: common vole; wood mouse; agriculture crops; rodent abundance; burrow index; snap trap; accuracy checking

The common vole, *Microtus arvalis* (Pallas, 1778; Rodentia, Cricetidae), is a major rodent pest in agricultural areas of central Europe (Zapletal et al. 1999, 2001; Jacob et al. 2014), as outbreaks can cause significant damage to crops. Monitoring the number of voles has become very important in making decisions on implementing preventive management or population control measures. In early 2000, the Central Institute for Supervision and Testing in Agriculture (CISTA), a Plant Health

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Division, provided a simple method for assessing the density of common voles. The method primarily counts the number of active burrows in a given area, takes only one day and can be used for various crops (Zapletal et al. 2001; Aulický et al. 2022).

As well as the common vole, mice species are also common on agricultural land, the most common being the wood mouse, *Apodemus sylvaticus* (Linné, 1758). Although this mouse is highly mobile, it also builds a small-scale burrow system. Tew (2000) questioned whether mouse burrows influence estimates of the number of active vole burrows.

The relationship between the number of voles/mice in each crop and the number of active burrows can be strongly influenced by the different food requirements of both species. The common vole is an herbivore that prefers green biomass, whereas the wood mouse is a granivore (Butet & Delettre 2011). Mice are much more mobile than voles and can move quickly to an attractive food source, such as mature crops (Ouin et al. 2000). The local environment provides the resources and conditions necessary for reproduction and survival (e.g. food and shelter) for both species. It shows considerable spatial and temporal variation, which is reflected in the abundance of the two species in different crops (Jacob et al. 2014; Heroldová et al. 2021a).

The actual abundance of small mammals is difficult to know but can be estimated with high accuracy by using snap traps (Jareňo et al. 2014). We aimed to determine whether the number of voles and mice is associated with the number of active burrows and vice versa. We also studied the effect of weed cover intensity in crops and the existence of permanent vegetation in the area (such as shrubs and trees), as well as whether these are related to the number of active burrows or the abundance of rodents within crops. This research is important because no studies evaluate the accuracy of the two most commonly used methods with the abundance of the common vole in the Czech Republic agroecosystem.

MATERIAL AND METHODS

The rodent population was monitored for two years (2004 and 2005) on selected crop fields in Southern Moravia (Czech Republic). The relationship between the number of active burrows (BI) and the number of rodents caught in snap-traps was studied on the same crop fields. The research was carried out in spring, a period recommended by the Division of Plant Health for monitoring small mammals (Zapletal et al. 2001). Spring BI indicates the overwintering vole population, which starts to reproduce in spring and summer. It is also the right time to decide on crop protection activities. It is important to determine the density of rodents, particularly common voles, to estimate the population size for at least the next two seasons.

Sampling was carried out on the most common crops in the area: alfalfa, winter rape, winter wheat, spring barley, maize and sunflower. Between 6 and 13 sites of each crop type were sampled each year, for a total of 112 crop fields in the area between Židlochovice and Břeclav (GPS coordinates 48.7945–49.0531 N, 16.5736–16.6179 E).

Snap-traps were baited with fried wicks (soaked in fat and flour) spread with peanut butter. A line of 50 snap traps (3 m apart) was placed at each site. The line was placed perpendicular to the crop field border, starting 50 m from the boundary to eliminate the boundary effect. The traps were left overnight and checked in the morning, for each captured individual, the species, sex, length and weight were recorded before dissection under laboratory conditions. The work was carried out per the European Council Directive 86/609/EEC on the experimental use of animals and with the applicable ethical standards (Act No. 246/1992) on protecting animals against cruelty (Animal Welfare Act).

Based on a count of active burrow entrances, the burrow index (BI) was calculated using CISTA, Plant Health Division methodology. An active burrow shows signs of small rodents, such as fresh food and faeces at the entrance, ingested vegetation around the burrow, digging in the ground and a clear entrance. The count was carried out using transects 100 m long (140 steps) and 2.5 m wide (1.25 m on each side of the transect). Four transects were established within each crop field (Zapletal et al. 2001). The number of active burrows in four transects (1 000 m^2) multiplied by 10 is the burrow index (BI) per hectare. The dates of the burrow counts were selected according to the plant cover in each crop. Alfalfa, winter wheat and winter rape were sampled in early April. Annual crops were monitored when rodent food was available (late May). Crop fields with vegetation approximately

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15 cm high were selected to ensure that burrow entrances were visible.

Weed cover was also assessed in each transect used to calculate BI as the percentage of the field area covered by weeds. The presence of permanent woody vegetation around each crop field within 100 m of its perimeter was assessed using an index. All plots were surrounded by at least herbal balks (index 1). If a shrub hedge was found, a value of 2 was assigned, and if a larger woody stand was found, an index of 3 was assigned.

It was analysed whether the BI, the number of common voles and wood mice captured, was influenced by year, crop, infestation level and the presence of permanent vegetation in the surroundings. The relationship between BI and the number of voles and mice captured was also studied. The analysis was performed for all crops and then for each crop.

The difference in the number of voles caught between 2004 and 2005 was analysed using a Mann-Whitney test. The same comparison between years was performed for the number of wood mice captured and BI. The Kruskal-Wallis test was used to determine the general influence of crop type on BI and the abundance of common voles and wood mice.

Given our data's limited number of repetitions, we decided to use a Bayesian approach. Using the MCMC algorithms, this approach allows repeated sampling to capture sufficient variability in the data. Therefore, this approach enables us to gain a more complete picture of the model's uncertainty through the posterior distribution. Additionally, since there were a lot of zeros in the data, we applied a zero-inflated count model for the analysis. This model includes two components: the binary component, which handles the excessive zeros, and the count component, which models the distribution of non-zero counts. The count component was modelled using BI abundances. The binary component, predicting the probability of zero occurrence, was informed by predictors such as the "surrounding vegetation type". This component accounts for biological and ecological factors that influence the occurrence of voles in different environments, such as the occurrence of scrubs/forests in the surrounding area, which may lead to an increase in abundance compared to grassland. The zero-inflated model allows us to detect differences in BI/abundances between plots surrounded by grassland (the "zero level"), and plots with shrubs or forest in their surroundings.

Multicollinearity among explanatory variables was addressed by calculating the variance inflation factor (VIF) for each explanatory variable using the "check_collinearity" function (Lüdecke et al. 2021). None of the explanatory variables exceeded a VIF value of 4. This result typically indicates that multicollinearity is not a problem but rather a concern and does not cause serious issues in the model.

To assess the dependence between BI or abundance and the characteristics of agricultural land and the surrounding landscape, we used a Bayesian generalised linear model with a "brm" function and the "brms" package with a zero-inflated Poisson error distribution (Bürkner 2017). We used locality and year as crossed factors with a random effect to account for spatial and temporal autocorrelation. We set a non-informative distribution in the model before model uncertainty in the parameters. We set 4 chains, each with 8 000 iterations, using Markov Chain Monte Carlo (MCMC) to achieve convergence and good mixing across multiple chains. The robustness of the MCMC simulations, ensuring convergence, was assessed using the R-hat statistic, which was below the threshold of 1.2, indicating good model convergence. All analyses were performed using the R software (R Development Core Team 2024).

We applied the chosen model to test our selected objectives:

(i) To determine a significant correlation between BI and the number of captured individuals, we used as a fixed factor, in one case, the abundance of wood mice and, in the other, the abundance of voles. In both cases, covariates included weed infestation, surrounding vegetation, and crop type.

(ii) To determine a significant correlation between variables BI/vole abundance/mice abundance and the dominant vegetation cover of the surrounding landscape, we used the surrounding vegetation as a fixed factor.

(iii) To determine a significant correlation between variables BI/vole abundance/mice abundance and the occurrence of field weeds, we used the level of weed cover as a fixed factor.

No analysis was performed for vole abundance in sunflower crop fields because no individuals were captured. Similarly, no analysis was performed for vole abundance in maize and wood mouse abundance in alfalfa because the zero-

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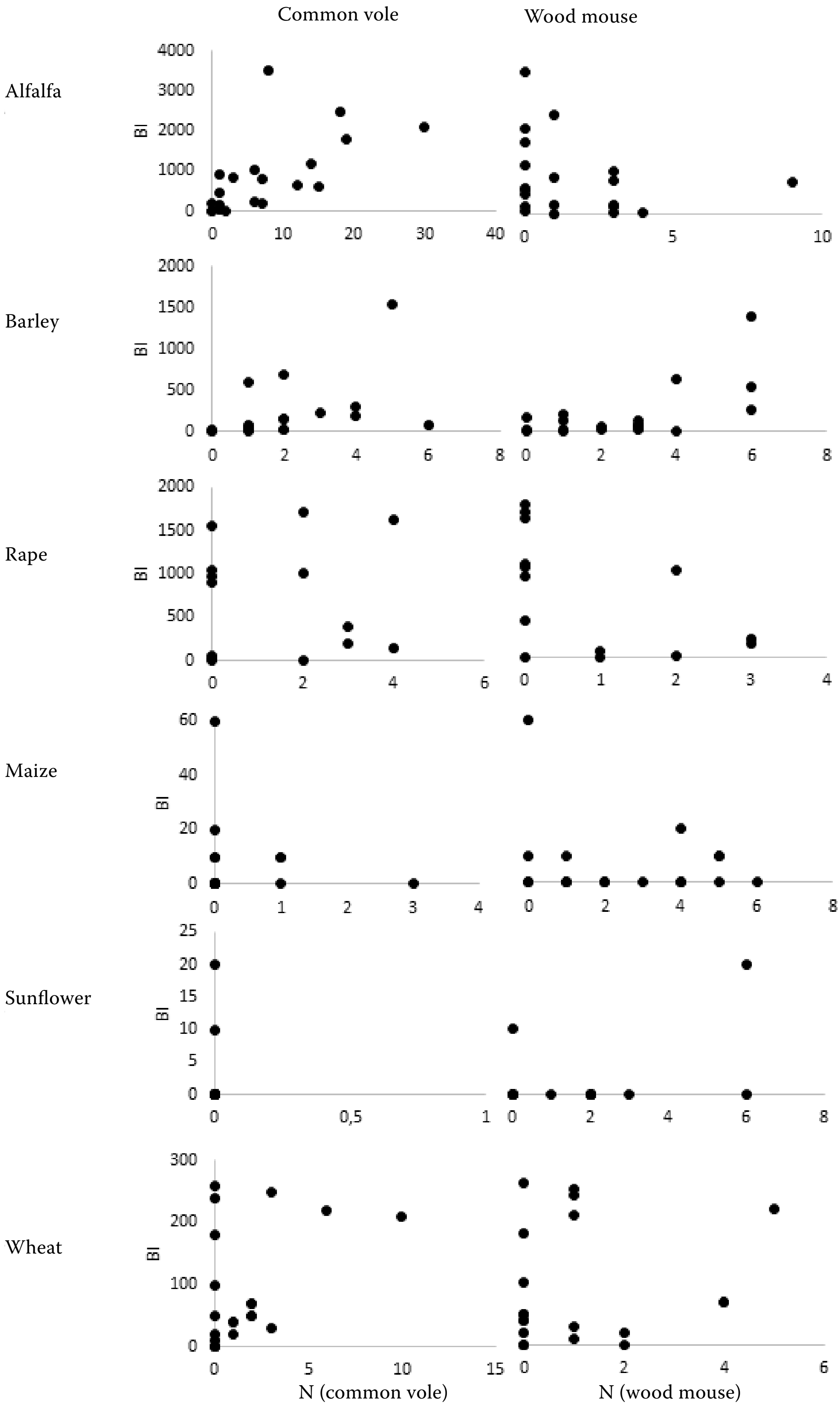

Figure 1. Relationship between BI (burrow index) and the number of common voles and wood mice captured in different crops

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Table 1. The summary of the burrowing index, the number of common voles/wood mice captured, the percentage of weed cover and the occurrence of permanent plots (PP)

		BI			Common vole			Wood mouse			Weed cover			PP
Crop	*N*	Mean ± CI	SD	Med (RG)	Mean ± CI	SD	Med (RG)	Mean ± CI	SD	Med (RG)	Mean ± CI	SD	Med (RG)	Mean
Total	112	296.6 ± 109.1	582.5	30 (0–3 520)	2.2 ± 0.83	4.46	0 (0–30)	1.7 ± 0.36	1.92	1 (0–9)	7.8 ± 2.05	10.9	5 (0–45)	1.96
Barley	19	225.3 ± 175.3	363.7	80 (0–1 540)	2.0 ± 0.78	1.65	2 (0–6)	2.6 ± 0.93	1.92	3 (0–6)	8.2 ± 4,24	8.79	5 (0–30)	2.32
Maize	20	6.0 ± 6.4	13.6	0 (0–60)	0.3 ± 0.33	0.71	0 (0–3)	2.5 ± 0.91	1.94	2 (0–6)	1.8 ± 1.06	2.26	0 (0–6)	1.85
Wheat	22	86.8 ± 40.0	90.2	50 (0–260)	1.6 ± 1.05	2.37	0.5 (0–10)	1.0 ± 0.65	1.48	0 (0–5)	4.0 ± 2.51	5.65	2 (0–20)	1.86
Rape	14	689.6 ± 359.6	622.7	656 (0–1 710)	1.4 ± 0.89	1.55	1 (0–4)	0.9 ± 0.65	1.12	0 (0–3)	10.7 ± 7.14	12.37	5 (0–45)	1.92
Sunflower	17	1.8 ± 5.1	5.1	0 (0–20)	0	0	0	1.7 ± 0.96	1.88	2 (0–6)	4.0 ± 3.33	6.47	0 (0–20)	2.00
Alfalfa	20	861.4 ± 432.8	924.7	625 (0–3 520)	7.55 ± 3.72	7.94	6 (0–30)	1.6 ± 1.02	2.18	1 (0–9)	19.0 ± 6.88	14.70	20 (0–40)	1.82

BI – burrowing index; N – the number of plots monitored; mean ± confidence interval (CI); SD – standard deviation; Med (RG) median and range
Mean permanent plot (PP) is derived from the index (1–3) of the surrounding vegetation: (1) herbaceous balks, (2) a shrub hedge, (3) a larger woody stand; no common vole was recorded in the sunflower

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Table 2. The relationship between BI and the number of common voles/wood mice captured, results of Bayesian GLM analysis (zero-inflated model)

	Common vole			Wood mouse		
Crop	PME	(l–95%) CI	(u–95%) CI	PME	(l–95%) CI	(u–95%) CI
Total	**0.001**	**0.000**	**0.001**	0.000	0.000	0.000
Barley	**0.001**	**0.000**	**0.002**	**0.001**	**0.000**	**0.001**
Maize	NC	NC	NC	0.028	–0.036	0.088
Wheat	**0.008**	**0.000**	**0.016**	0.002	–0.005	0.008
Rape	0.000	0.001	–0.001	**–0.002**	**–0.006**	**0.000**
Sunflower	NA	NA	NA	0.050	–0.059	0.164
Alfalfa	**0.001**	**0.000**	**0.002**	0.000	–0.001	0.001

PME – Posterior Mean Estimate; CI – credible intervals (a significant effect is highlighted in bold, l – lower, u – upper); NC – no results as the model did not converge; the estimated effect sizes (PME) are on a logarithmic scale; to convert them to the original scale of the dependent variable, an exponential transformation must be applied

Table 3. The relationship between BI and percentage of weed cover and the presence of permanent plots (shrubs and forests) in the surrounding area overall and in each habitat, results of Bayesian GLM analysis (zero-inflated model)

	Weed cover			Shrubs			Forests		
Crop	PME	(l–95%) CI	(u–95%) CI	PME	(l–95%) CI	(u–95%) CI	PME	(l–95%) CI	(u–95%) CI
Total	**0.048**	**0.049**	**0.050**	**–0.323**	**–0.355**	**–0.291**	0.022	–0.019	0.064
Barley	–0.118	–0.056	–0.018	–0.588	–4.482	3.194	**–1.506**	**–1.591**	**–1.425**
Maize	0.025	–1.303	1.271	NC	NC	NC	NC	NC	NC
Wheat	**–0.017**	**–0.026**	**–0.008**	**–0.547**	**–0.714**	**–0.380**	–0.570	–2.596	1.427
Rape	**0.033**	**0.030**	**0.037**	0.077	–0.003	0.157	–0.278	–1.510	1.044
Sunflower	**NC**	**NC**	**NC**	–1.600	–5.468	1.567	2.543	–3.426	10.395
Alfalfa	**0.057**	**0.055**	**0.059**	**–0.255**	**–0.314**	**–0.166**	**–1.506**	**–1.591**	**–1.425**

PME – Posterior Mean Estimate; CI – credible intervals (a significant effect is highlighted in bold, l – lower, u – upper); NC – no results as the model did not converge. The estimated effect sizes (PME) are on a logarithmic scale; to convert them to the original scale of the dependent variable, an exponential transformation must be applied

Table 4. The effect of the percentage of weed cover on the abundance of common vole and wood mouse, results of Bayesian GLM analysis (zero-inflated model)

	Common vole			Wood mouse		
Crop	PME	(l–95%) CI	(u–95%) CI	PME	(l–95%) CI	(u–95%) CI
Total	0.006	0.017	–0.028	0.012	–0.017	0.041
Barley	0.020	–0.031	0.072	0.019	–0.024	0.069
Maize	NC	NC	NC	–0.075	–0.262	0.111
Wheat	–0.096	–0.420	0.258	–0.012	–0.146	0.107
Rape	–0.003	–0.063	0.061	–0.096	–0.407	0.128
Sunflower	NA	NA	NA	–0.018	–0.134	0.104
Alfalfa	0.006	–0.040	0.055	0.015	–0.017	0.048

PME – Posterior Mean Estimate; CI – credible intervals (a significant effect is highlighted in bold, l – lower, u – upper); NC – no results as the model did not converge; NA – no voles captured
The estimated effect sizes (PME) are on a logarithmic scale; to convert them to the original scale of the dependent variable, an exponential transformation must be applied

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Table 5. The influence of permanent plots (shrubs and forest) in the surrounding area on the abundance of common vole/wood mouse, results of Bayesian GLM analysis (zero-inflated model)

	Common vole						Wood mouse					
	Shrubs			Forests			Shrubs			Forests		
Crop	PME	(l–95%) CI	(u–95%) CI	PME	(l–95%) CI	(u–95%) CI	PME	(l–95%) CI	(u–95%) CI	PME	(l–95%) CI	(u–95%) CI
Total	–0.336	–1.186	0.718	0.458	–0.313	1.527	**1.845**	**0.748**	**3.051**	**2.082**	**0.992**	**3.278**
Barley	0.903	–1.806	4.436	0.998	–1.651	4.489	0.129	–1.555	1.753	0.465	–1.131	2.122
Maize	NC	NC	NC	NC	NC	NC	0.950	–0.260	2.305	**1.410**	**0.120**	**3.069**
Wheat	0.865	–2.093	3.750	2.015	–1.896	5.217	0.224	–1.466	1.931	1.322	–0.999	3.534
Rape	–0.681	–3.393	2.021	1.178	–1.035	4.189	–0.295	–3.765	3.198	1.225	–1.213	4.450
Sunflower	NA	NA	NA	NA	NA	NA	0.701	–1.701	2.810	0.458	–2.994	3.558
Alfalfa	–0.662	–1.944	0.785	0.006	–1.409	1.603	**1.771**	**0.436**	**3.241**	**1.810**	**0.454**	**3.277**

PME – Posterior Mean Estimate; CI – credible intervals (a significant effect is highlighted in bold, l – lower, u – upper); NC – no results as the model did not converge; NA – no voles captured

The estimated effect sizes (PME) are on a logarithmic scale; to convert them to the original scale of the dependent variable, an exponential transformation must be applied

inflated model could not be used due to the lack of variability in the data.

RESULTS

A total of 248 common voles, 193 wood mice and 80 individuals of other small mammal species (20 *Apodemus uralensis*, 34 *A. flavicollis,* 10 *Sorex araneus,* 16 *Mus musculus*) were captured. No significant differences in BI were found between 2004 and 2005 (z = 1.413, P = 0.158). However, fewer mice and voles were trapped in 2004 than in 2005 (mean ± confidence interval: mice 1.08 ± 0.38 (2004) and 2.55 ± 0.50 (2005), z = 3.754, P < 0.001; voles 1.35 ± 0.75 (2004) and 2.89 ± 1.37 (2005), z = 3.170, P = 0.0015). The number of burrows varied between crops (z = –5.885; P < 0.001), with the highest numbers found in alfalfa and winter rape (Table 1). Crop type also affected the number of voles (z = –5.221; P < 0.001) and mice (z = 2.174; P = 0.029) captured (Figure 1).

In general, there was a statistically significant positive relationship between both BI and the number of common voles trapped (Table 2). However, when analysed by crop type, this relationship was highly significant only for alfalfa, wheat and barley voles. For wood mice, a positive relationship was found in barley, but a negative one in winter rape (Table 2).

In general, there is a relationship between weed cover and BI (Table 3). This is positive for rape and alfalfa and negative for barley and wheat. However, there was no direct relationship between weed infestation and vole or mouse abundance (Table 4).

Permanent areas in the vicinity impact both BI and rodent abundances. The presence of shrubs in the vicinity negatively influenced the BI in total crop fields and winter wheat and alfalfa crops (Table 3). The presence of surrounding forests negatively influenced the BI of barley and alfalfa. There was no effect of permanent plots on the relative abundance of voles. However, the total mouse sample and the alfalfa crop confirmed a positive influence of nearby scrub and forest. Forest near maize fields increased the abundance of mice (Table 5).

DISCUSSION

Small mammals use agricultural land depending on the quality of the habitat and the extent to which it meets their needs. This was observed in the considerable variation in the number of active burrows, BI, and rodents trapped in different crops. The Czech Division of Plant Health under the CISTA classifies rodent density in spring as high if the BI is greater than 200, which was found in our field study in barley, winter rape and alfalfa crops. On the contrary, lower densities, with a BI of less than 50, were found in sunflower and maize crops. We found that, under certain conditions, BI reflects the abundance of the common voles, but not

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of wood mice, which are the second most abundant "pest species" in the study area.

Small mammal communities tend to be more stable in habitats that provide food for longer periods, i.e. those with permanent or winter crops. In the Czech Republic, these are permanent alfalfa, winter wheat and winter rape (Jánová et al. 2011). In these crops, rodent burrows are more abundant and remain active longer. In crops with high vole abundance, such as alfalfa, winter wheat and spring barley, a relationship was found between BI and the number of voles trapped. In contrast, in winter rape crops, the number of voles was much lower than expected according to the BI. It is possible that winter rape crops provide better conditions for the common vole to survive the winter (good food and shelter) than any other crop (including alfalfa), and sometimes even winter breeds are observed (Suchomel et al. 2023). This is explained by the intensive activity of voles in rape during the winter (Heroldová et al. 2021a, b). Winter mortality is high in early spring (Jacob et al. 2014). As a result, many active burrows during the autumn and winter may be underpopulated in spring, and the number of active burrows may be overestimated compared to other crops. A negative correlation was found between BI and wood mouse abundance in rape. A good cover of winter rape provides safe movement for mice. Habitat use appears to largely respond to the availability of cover in the field (Tew et al. 2000).

According to Liro (1974), each common vole usually occupies two or more burrows in spring. This may change in mild winters with low mortality, or when there is increased burrowing activity due to winter breeding and there are many more burrows per individual (Suchomel et al. 2023). Wood mice also burrow and breed in crops (Ouin et al. 2000; Green 2009), but the burrow systems used by voles and wood mice differ due to their different foraging and anti-predator behaviours. Common voles can be active and feed throughout the day and night, with bursts of activity approximately every 3 h. This high feeding frequency leads them to build burrows to provide temporary shelter from predators. Evidence shows that the vole burrow system expands as they spend more time in a crop field (Jacob et al. 2014; Santamaria et al. 2019). In contrast, wood mice feed only at dawn and dusk and build simple burrows, usually with only two entrances (Butet & Delettre 2011).

Burrow systems in arable fields are mainly the work of voles. However, in some crops preferred by mice rather than voles, mouse burrows may be counted as vole burrows and vole density may be overestimated (Tew et al. 2000). For crops less used by voles, such as maize and sunflower (Jánová et al. 2011), no relationship between vole numbers and BI was found, or at least not analysed, because very few or no voles were captured. This may be because these two crops do not provide a suitable food source for voles. The low abundance of common voles in all phenological stages of both crops may be of practical use in agricultural management, as they may serve as an isolation zone to protect more attractive crops (such as alfalfa and spring barley) from vole migration.

Another method used to study rodent abundance is counting the number of reopened burrows, which provides similar results to BI (Lisická et al. 2007). While this method is unreliable at low abundance levels, it is highly reliable at high population densities. During our study, some crops had high densities of common voles, and our counts were considered reliable. Control is usually recommended when there are 500 or more burrow entrances (Zapletal et al. 2001; Lisická et al. 2007).

There was no effect of the relative abundance of the rodents and weed cover on any crop. Still, a positive relationship was confirmed between the BI and weed cover, most pronounced in alfalfa and winter rape. This is related to vole preferences in these crops, as their negative impact causes weed infestation (Heroldová et al. 2021a). A negative relationship between weed cover and BI was found in barley and wheat. This can be explained by anti-predator behaviour, as bird predation is high in unconnected vegetation cover. In these plots, weeds are a valuable source of food and shelter; in more weedy fields, voles do not need to build a large burrow system (Jacob et al. 2014; Santamaria et al. 2019).

The presence of shrubs and woodlands around the fields reduced BI in the whole sample, especially in alfalfa. This is a positive effect for Plant Protection Practice as more diverse surroundings may lead to higher predator activity and lower vole activity (Tew et al. 2000; Tattersall et al. 2001). Permanent woody vegetation around crops has a positive effect on the abundance of mice in crops, but not on the abundance of voles. Mice are highly mobile and therefore depend on the proximity of attractive fields to surrounding

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shrub and woodland, as mouse burrows are preferably built in permanent vegetation. Permanent vegetation, especially woody vegetation, has a stabilising function in agricultural landscapes. They can act as a reserve for small mammals during the winter, as a refuge during agricultural activities, providing food and shelter (Rodríguez-Pastor et al. 2016; Tew et al. 2000; Bryja & Zukal 2000). However, they can also be a temporary refuge for field pests such as the common vole (Maisonneuve & Rioux 2001). Granivorous species, such as *Apodemus* mice are usually neglected as pests. However, they can successfully colonise adjacent crop fields (Tattersall et al. 2001; Green 2009) and have become important pests of seed-bearing crops (Heroldová et al. 2004).

According to Jánová and Heroldová (2016), fallow plots could play an important role in reducing the negative impact of rodents on crops in intensively managed agricultural landscapes, as they provide attractive habitats for small mammals throughout the year. Highly diverse agricultural habitats with riparian strips, road verges, small forests and windbreaks show increased plant and animal species diversity and act as a centre of biodiversity (Schwartz & Witson 1987; Southerton 1998).

CONCLUSION

In the Czech Republic, the abundance of the common vole in crops is monitored by the methodology of the Plant Health Division, which is based on a count of active burrow entrances (index BI). We assessed the relationship between the burrow index and the relative abundances of the rodent species studied by snap trapping. Based on snap trap data, it was found that in the higher density crops, BI had a clear relationship with common vole abundance. In contrast, BI was not related to wood mouse densities. Permanent plots around the crops reduced BI and increased wood mouse abundances, but their influence on vole abundance was not confirmed.

The active burrow counting method (BI) is a faster, cheaper and non-invasive method that allows monitoring of a larger area and provides acceptably accurate information (Engeman 2005). It can be concluded that BI is a reliable indicator of vole abundance, but it is not very accurate at low densities and in fields that are rarely used by voles.

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