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Spatiotemporal Variation of Small Mammal Communities in Commercial Orchards across the Small Country

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Abstract: The diversity of small mammal communities is a measure of the sustainability of habitats, especially agricultural ones. Based on 2018–2020 data from 18 sites in Lithuania, we analysed factors related to diversity of such a community, specifically the relative abundances and proportions of common vole, striped field mouse, yellow-necked mouse, and bank vole. We assessed the influence of location (central, northern, eastern, southern, and western parts of the country), habitat type (orchards, berry plantations, control habitats), the year and season. The model explained 14.8–33.4% of the listed parameters with $p < 0.005$ or higher, with the exception of the dominance index and the proportion of the common vole. Time factor (year and season, $p < 0.001$) and site location ($p < 0.05$) had the highest influences, while that of habitat type was less significant. The results of this and the former research suggest that commercial orchards play a role in maintaining the diversity and abundance of small mammal communities in the agrolandscapes.

Keywords: rodents; population indices; spatio-temporal variation; agricultural habitats; Lithuania; northern zone

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1. Introduction

Temporal and spatial variability is inherently characteristic to all mammals, including small mammals, and their communities [1–4]. Climate and availability of food are two general factors that influence the abundance of animals [5], with habitat being a third one [6]. The structures and dynamics of small mammal communities are related to the habitats they live in [7], including forests [8] and those of agricultural origin [9–12].

It is universally accepted that agriculture is one of the main drivers of ecosystem degradation and of biodiversity loss. For example, the threat level to birds might be predicted from data of land use for agricultural activities and densities of human population [13]. Nearly all productive land is already used for agricultural production [14], therefore with the aim of preserving biodiversity, humankind seeks solutions on the harmonization of the need for foods and nature conservation. It should be recognized that biodiversity might become an integral part of farmland if it is managed with the incorporation of some conservation measures [15,16].

In Europe, most conflicts between agriculture and biodiversity conservation have been identified already, namely "the intensification of agriculture, the abandonment of marginally productive but High Nature Value Farmland, and the changing scale of agricultural operations" [17]. According to EEA [18], there are three types of habitats, defined as High Nature Value Farmland: (i) farmland with semi-natural vegetation, (ii) farmland with low intensity agriculture, and (iii) farmland supporting threatened species or containing significant proportion of European or the world populations of the other species.

The question of using indicators of biodiversity for sustainable agriculture has a theoretical framework [19]. Using Italy as a case study, an index of a vertebrate biodiversity based on a multi-taxa approach was developed for an intensively cultivated and highly inhabited area, identifying groups suitable to be used as a proxy of biodiversity [20]. These authors found the most suitable vertebrate groups were birds and reptiles, while other taxa, including mammals, did not correlate with a general biodiversity index.

Small mammals, and particularly rodents, however, are very important in the agricultural landscapes, as they are mostly treated as pests [21–23], causing economic impacts on crop production [24] and damage in the forests [25]. Rodent outbreaks have been explained as an answer to weather parameters and climate [26,27], but they have also been related to monoculture production [28], pest control problems, and ecosystem dysfunction [29,30].

Fruit orchards and berry plantations are agricultural habitats supporting various small mammal species depending on the latitude [31–36] and crop [37–39]. Over the last five decades, in Lithuania the general trend of land use has had an overall increase in the area of forest and a decrease in the area of crops and meadows [40]. The same trend has been characteristic to commercial orchards in Lithuania: their area decreased from 58.9 thousand ha in 2013 to 17.3 thousand ha in 2021 [41]. Small mammal research in Lithuanian commercial orchards started in 2018, presenting first data on species composition [39], focal species [42], the trophic niches of granivore [43] and herbivore [44] small mammal species, and small mammal fertility data [45].

Despite their importance to biodiversity in the agricultural landscape, knowledge on the spatiotemporal variability of small mammals in commercial orchards is still poorly documented. The aim of the current study is to analyze temporal and small-scale spatial variability of the small mammal community and the most abundant species in the commercial orchards and control habitats, assessing the influence of location, habitat, year, and season in detail on the relative abundance and proportions of the species inhabiting this specific type of agricultural lands.

2. Materials and Methods

2.1. Study Sites

The investigation covered 18 study sites across Lithuania (northern Europe) in 2018–2020, representing central (55.58° N, 23.86° E), northern (55.97° N, 25.01° E), eastern (55.60° N, 25.27° E), southern (54.29° N, 24.24° E), and western (55.44° N, 22.22° E) parts of the country [39], crop types and agricultural practices, such as grass mulching, mowing, soil scarification, and application of plant protection agents and rodenticide. We were not able to create systematic sampling design with all categories. Crops were the following: commercial apple and plum orchards, plus currant, raspberry, and highbush blueberry plantations (Figure 1). The control habitats were mowed meadows, unmoved meadows, and forest ecotones, and one of these was located adjacent to each orchard or plantation. Sites 1–3, 6–10, and 12 were investigated in 2018–2020, while sites 5, 7, 9, 11, and 13–15 were studied in 2018–2019 and sites 16–18 were studied in 2020. The average size of the study site was 37.6 ± 11.9 ha (63.7 ha of apple orchards, 0.81 ha of plum orchards, 22.0 ha of currant plantations, 2.3 ha of raspberry plantations, and 3.80 ha of blueberry plantation).

Crops were of different ages and intensities of agricultural practices. Crop age categories were old, medium aged, and young, while intensity categories were low, medium, and high. Agricultural practices included grass mulching, mowing, soil scarification, and application of plant protection agents and rodenticides. The intensity of agricultural practices was high (frequent application of two or more of the above-listed measures, including rodenticides), medium (two listed measures during the crop season, once or twice during the season), or low (removal of grass only). Distribution of study sites according to these parameters is presented in the Table 1, and additional details of classification are in [39,42].

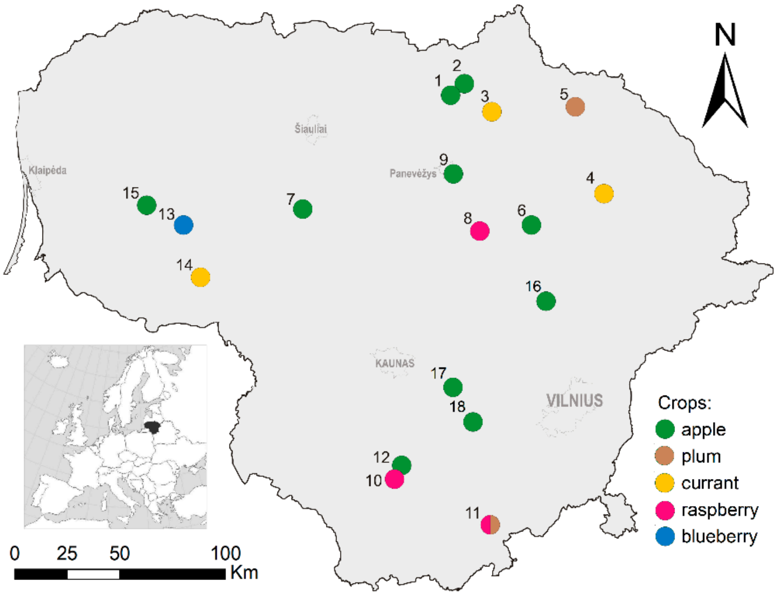

Figure 1. Location of the study sites in Lithuania with an indication of the crops (adapted from [42]).

Table 1. Trapping effort in 2018–2020 according to crop age, intensity of agriculture, and control habitat type.

Parameter	Values	Sites	Trapping Effort
Crop age	old	1, 2, 6, 7, 9, 12, 16–18	9768
	medium	3, 4, 8, 11, 13–15	5050
	young	1, 5, 10, 12	1900
Intensity of agriculture [1]	high	2, 6, 10–13, 15, 17	8218
	medium	1, 5, 9, 14	4450
	low	3, 4, 7, 8, 11, 16, 18	4050
Control	forest	11, 17	525
	mowed meadow	1, 2, 4, 6, 8–10, 12, 13–16	5560
	non-mowed meadow	1, 3, 5, 7–9, 11, 18	2700

[1] Depending on soil scarification, grass mowing, mulching of the plant interlines, and the usage of rodenticides and plant protection agents, we characterized three levels of intensity. Sites with only grass mowing once or several times per season were attributed to low intensity, while usage of two measures from those above listed once or twice per season was defined as medium intensity. Application of several measures or frequent application of two measures per season was defined as high intensity.

2.2. Small Mammal Trapping

Small mammals were trapped using snap-traps. According to the standard [46], traps were set in lines of 25 traps at 5 m intervals, exposition three days, checked once per day in the morning. The bait was brown bread and raw sunflower oil, changed after rain or when consumed. Trapping was conducted in summer (June) and autumn (September–October). During 2018–2020, the total trapping effort was 25,503 trap days, divided between 16,718 for the orchards and 8785 for the control habitats (Table 1). Unequal trapping effort was related to the availability of different orchards and their control habitats.

Trapped small mammals were identified by their external features, with grey voles of the genus *Microtus* by their teeth at dissection and after cleaning skulls [47]. The most abundant species in the small mammal communities were common voles (*Microtus arvalis*), yellow-necked mice (*Apodemus flavicollis*), striped field mice (*Apodemus agrarius*), and bank voles (*Clethrionomys glareolus*), totaling 30.1%, 25.7%, 23.9%, and 11.3% of all trapped individuals, respectively.

2.3. Data Analysis

The analyzed indices of the small mammal communities were number of species, dominance, diversity (Shannon's H), and relative abundance (number of individuals trapped per 100 trap/days). The diversity index and dominance index were calculated in PAST version 4.01 (Paleontological Museum, University of Oslo, Oslo, Norway). We used standard statistics (average and 95% CI) for these parameters. Trapping session (three day trapping in one habitat, particular year, and particular season) was used as a sampling unit. Average values for all these indices per each trapping session (n = 168) were calculated and used as primary data. To keep compatibility to the published data and maintain interpretability of relative abundances, data were not transposed.

The analyzed indices of the four most abundant species were the proportion and the 95% CI for the species among all trapped small mammals and the relative abundance of the species. The proportions and the 95% CI for species proportion were calculated with the Wilson method of the score interval [48] using OpenEpi epidemiological software [49]. Differences in the proportions of the most abundant species between habitats, crop ages, and intensities of agricultural measures were evaluated using the G test with online calculator [50]. Effect size was expressed according to adjusted Cohen's w [51], calculated in WinPepi, version 11.39 (Abramson, J., Jerusalem, Izrael).

We used the GLM (generalized linear model) to find the influence of the categorical factors, namely habitat type (orchards, berry plantations, control habitats), age of the orchard or plantation, intensity of agriculture, year, season, and location (central, northern, eastern, southern, and western parts of the country), on the dependent parameters listed above. To control data variability, trapping effort was used as a continuous predictor. Hotelling's T^2 was used to test the significance of the model and eta-squared for the influence of the categorical factors.

Before running GLM, we tested the normality of the distribution of the dependent parameters via Kolmogorov–Smirnov's D. We applied Tukey HSD with unequal N for post-hoc analysis. The confidence level was set as $p < 0.05$. At the level $p < 0.10$, we supposed a trend, but not a difference, would exist. Calculations were done in Statistica for Windows, version 6.0 (StatSoft, Inc., Tulsa, OK, USA).

3. Results

Trapping effort controlled GLM confirmed the cumulative influence of location (Hotelling's $T^2 = 0.69$, $p < 0.05$), season ($T^2 = 0.50$, $p < 0.001$), year ($T^2 = 0.79$, $p < 0.001$), habitat ($T^2 = 0.98$, $p < 0.05$), and intensity of the agricultural practices ($T^2 = 0.37$, $p < 0.05$) on the proportions and relative abundance of the most numerous species as well as on the diversity and abundance of the small mammal communities, explaining 14.8%, 33.4%, 27.5%, 13.8%, and 15.2% of the variation, respectively. These influences were constrained with trapping effort ($T^2 = 0.43$, $p < 0.001$) being highly significant and strong (eta-squared = 0.30). Age of the fruit habitat had no influence ($T^2 = 0.28$, $p = 0.29$).

Based on the GLM results, we further analyzed the effects of the year and season as factors of temporal variation and the effects of location and fruit type as factors of spatial variation on abundances, on diversity parameters, and on the proportions of species in the small mammal communities.

We excluded factors such as age of the crop and agricultural intensity from detailed analysis as they required a different approach, despite the last one being significant.

3.1. Temporal Trends of Small Mammal Diversity and Abundance

As a single factor, year had a significant influence on the diversity of small mammal communities ($F_{2,165} = 4.84$, $p < 0.01$) and on the proportions of *A. agrarius* (G = 33.0, $p < 0.001$; minimum in 2019, 16.1%, 95% CI = 13.4–19.4%) and *A. flavicollis* (G = 25.9, $p < 0.001$; minimum in 2018, 17.2%, CI = 14.2–20.7%). Proportions of *M. arvalis* were more stable (G = 12.6, $p < 0.02$; maximum in 2019, 36.7%, CI = 32.9–40.7%), while those of *C. glareolus* did not differ (G = 4.4, $p > 0.10$; Figure 2).

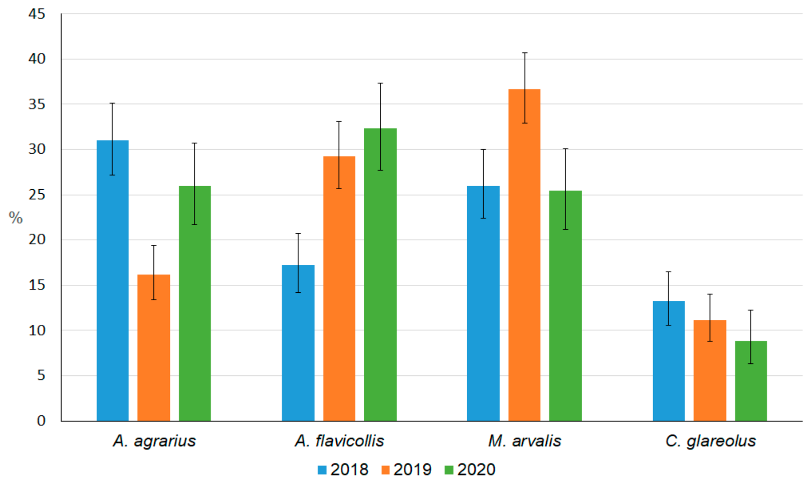

Figure 2. Yearly changes in the proportions (95% CI) of the four most abundant small mammal species in the commercial orchards in 2018–2020.

The diversity of the small mammal community was highest in 2018 (Shannon's H = 1.73, CI = 1.66–1.79), exceeding that in 2019 (H = 1.56, CI = 1.49–1.63; $t = 3.30$, $p < 0.001$) and in 2020 (H = 1.55, CI = 1.47–1.62. $t = 3.45$, $p < 0.001$), being equal in the last two years. The number of species trapped in 2018, 2019, and 2020 did not differ significantly, being 10, 11, and 9, respectively, as well as the Simpson's dominance index, D, being 0.22., 0.26, and 0.25.

Differences in the relative abundances between years were not significant, not for any of the most abundant species nor for the community as a whole, with even maximum abundances of the species being quite similar (Table 2).

Table 2. Relative abundances (individuals per 100 trap-days) of the small mammal communities and the most numerous species in commercial orchards, 2018–2020. Based on ANOVA F and Tukey's HSD, no differences between years were significant.

Relative Abundance	2018			2019			2020			$F_{2,165}$	*p*=
	Mean	SE	Max	Mean	SE	Max	Mean	SE	Max		
M. arvalis	1.5	0.3	10.0	2.4	0.7	26.7	1.2	0.4	13.3	1.81	0.17
A. flavicollis	1.0	0.2	8.0	1.8	0.4	12.7	2.0	0.5	14.7	2.25	0.11
A. agrarius	2.1	0.5	16.0	1.3	0.4	16.0	1.6	0.6	17.3	0.67	0.52
C. glareolus	1.0	0.4	15.3	0.84	0.2	10.7	0.7	0.2	5.3	0.13	0.88
Community	6.2	1.1	36.0	6.9	1.1	44.7	5.8	1.2	36.0	0.23	0.79

Seasonal trends were significant for the diversity index, the relative abundance of the community, for *M. arvalis*, *A. flavicollis*, and *A. agrarius* (HSD, all $p < 0.001$), and *C. glareolus* (HSD, $p < 0.02$), all these indices being higher in the autumn than the summer. The relative abundance of *M. arvalis* and *A. flavicollis* tripled, that of *C. glareolus* doubled, and that of *A. agrarius* increased by nearly 15 times (Table S1).

The number of species was equal, 10 in both seasons, and the dominance did not differ. The proportions of *M. arvalis* and *A. flavicollis* remained unchanged, while the proportion of *A. agrarius* significantly increased in autumn (from 5.9% to 28.6% of all trapped individuals), whereas *C. glareolus* significantly decreased (from 17.2% to 9.8%).

3.2. Location-Based Differences of Small Mammal Diversity and Abundance

The location in the country had no influence upon the number of small mammal species present in the commercial orchards, as nine species were trapped in each part (Figure 3). The proportions of the four most abundant species, however, were different. The proportion of *A. flavicollis* was smallest in the west (9.1%, CI = 3.1–23.6%) and highest in the central part (30.9%, CI = 26.1–36.2%), and the difference between the locations was significant (G = 32.1, $p < 0.001$). The proportion of *A. agrarius* (G = 23.3, $p < 0.001$) was smallest in the east (18.0%, CI = 14.3–22.3%) and highest in the north (31.9%, CI = 27.0–37.2%). *M. arvalis* proportions were high in the north (43.8%, CI = 38.4–49.3%) and especially in the east (49.9%, CI = 44.7–55.1%) of the country, significantly exceeding those in central and southern parts (G = 274.8, $p < 0.001$). The *C. glareolus* proportion in the orchards of northern Lithuania was negligible (0.9%, CI = 0.3–2.7%) and highest proportion was characteristic to central Lithuania (21.9%, CI = 18.2–26.1%), with the geographic differences being significant (G = 119.9, $p < 0.001$).

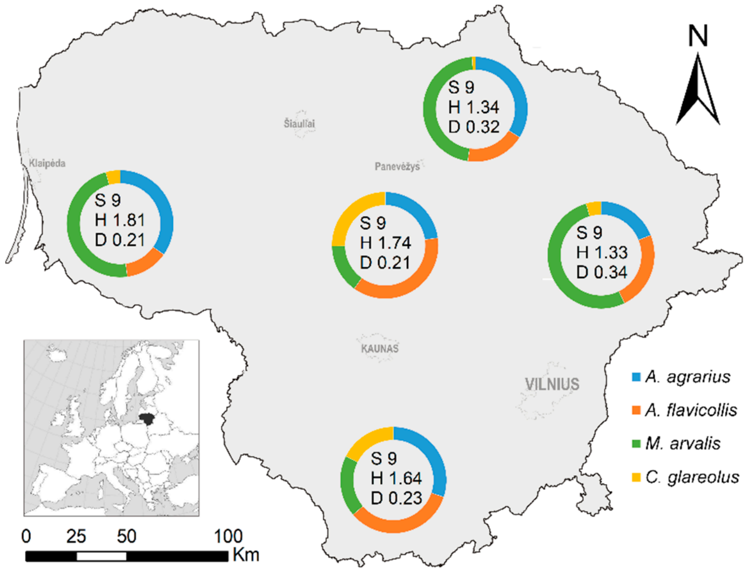

Figure 3. Proportions of the four most abundant small mammal species from the commercial orchards in different parts of Lithuania, 2018–2020. S—number of species, H—diversity, D—dominance indices.

According to the diversity of the small mammal communities in the commercial orchards, Lithuania breaks down into two types of territories: the first with high diversity (western, central, and southern part) and the second with low diversity (northern and eastern parts). Based on t-statistics, there are no differences within each group (W, S, and C: $t = 0.46$–1.75, $p > 0.08$; N, and E: $t = 0.18$, $p > 0.85$), while intergroup differences are all significant ($p < 0.05$–0.001). The situation with dominance is similar, dominance being significantly higher in northern and eastern parts (Figure 3).

The relative abundances of small mammals differed in relation to the position in the country (Table 3). Geographic differences were expressed for total abundance ($F_{4,163} = 3.33$, $p < 0.02$) and for those of *C. glareolus* (F = 5.14, $p < 0.001$), *A. flavicollis* (F = 3.91, $p < 0.005$) and *M. arvalis* (F = 2.54, $p < 0.05$), but not significantly in *A. agrarius* (F = 1.08, $p = 0.37$).

Table 3. Geographic differences of analyzed small mammal populations and species indices (RA—relative abundance, individuals per 100 trap-days; N—northern, E—eastern, S—southern, W—western, C—central part of the country), data from 2018–2020 pooled. Different superscript letters denote significant differences of averages, based on the HSD test, at $p < 0.05$.

Index	N Lithuania			E Lithuania			S Lithuania			W Lithuania			C Lithuania		
	Mean	SE	Max	Mean	SE	Max	Mean	SE	Max	Mean	SE	Max	Mean	SE	Max
RA of the community	4.3^{a}	1.2	27.3	7.4^{a}	1.7	44.7	7.5^{a}	1.4	36.0	2.0^{b}	0.8	14.7	8.9^{a}	1.5	36.0
RA of *M. arvalis*	1.6^{a}	0.5	10.0	3.5^{a}	1.2	26.7	1.3^{ab}	0.3	8.0	0.7^{b}	0.3	5.3	1.4^{ab}	0.5	13.3
RA of *A. flavicollis*	0.8^{b}	0.4	12.7	1.6^{a}	0.4	9.3	2.0^{a}	0.5	14.7	0.2^{b}	0.1	2.1	2.6^{a}	0.6	14.0
RA of *A. agrarius*	1.6^{a}	0.4	17.3	1.4^{a}	0.6	16.0	2.5^{a}	0.7	17.3	0.5^{a}	0.4	8.0	1.7^{a}	0.6	16.0
RA of *C. glareolus*	0.1^{b}	0.03	0.7	0.5^{b}	0.2	4.0	1.1^{a}	0.4	0.8	0.03^{b}	0.03	0.7	2.1^{a}	0.6	15.3

Total abundance was highest in the orchards of central sites, exceeding that in the western part (HSD, $p < 0.02$). The abundance of *M. arvalis* in the eastern part was higher than in the western ($p < 0.05$), and the abundance of *A. flavicollis* in the eastern part was higher than in the western ($p < 0.01$) and northern ($p < 0.05$) parts. The abundance of *C. glareolus* in orchards of the central part of the country exceeded that in the western ($p < 0.005$), northern ($p < 0.001$), and eastern ($p < 0.05$) parts. As for the abundance of *A. agrarius*, no geographic differences were found.

3.3. Habitat-Based Differences of Small Mammal Diversity and Abundance

Comparing crop (control habitat)-based differences from ANOVA analysis, effects were expressed for the number of species ($F_{7,160} = 2.26$, $p < 0.05$), the diversity of the community ($F = 2.41$, $p < 0.05$), and the relative abundance of *C. glareolus* ($F = 3.99$, $p < 0.001$), as well as for the proportions of *A. agrarius* ($G = 36.8$), *A. flavicollis* ($G = 83.5$), *M. arvalis* ($G = 169.8$), and *C. glareolus* ($G = 56.1$), all significant at $p < 0.001$. Data on abundances and proportions, including the results of the paired comparisons, are presented in Table 4. Bilberry orchard is not included as no small mammals were trapped during 2018–2019. To check whether differences in diversity and the number of species were related to trapping effort in unequally represented fruit and control habitats, we did rarefaction analysis for the number of species and diversity index. Under low to medium trapping effort, these differences were negligible (Figure S1).

Table 4. Habitat-based differences of analyzed small mammal populations and species indices (RA—relative abundance, individuals per 100 trap-days; SE—standard error; %—proportion; CI—confidence interval), data from 2018–2020 pooled. Different superscript letters denote significant differences, based on the HSD, t and G tests, at $p < 0.05$. Fruit types: AO—apple orchards, PO—plum orchards, CP—currant plantations, RP—raspberry plantations, controls: MM—mowed meadows, NM—non-mowed meadows, FO—forest ecotones.

Index		Fruit Types				Controls		
		AO	PO	CP	RP	MM	NM	FO
Community	RA	6.0, SE = 1.1	4.3, SE = 1.6	6.6, SE = 3.2	6.6, SE = 2.2	6.7, SE = 1.1	6.3, SE = 1.9	12.8, SE = 5.0
	S	9 ^{a}	3 ^{c}	6 ^{b}	6 ^{b}	11^{a}	8 ^{a}	6 ^{b}
	H	1.61 ^{b}	0.93 ^{d}	0.86 ^{d}	1.29 ^{c}	1.78 ^{a}	1.63^{b}	1.27^{c}
	D	0.24 ^{c}	0.45 ^{a}	0.54 ^{a}	0.31 ^{b}	0.21 ^{c}	0.23 ^{c}	0.31 ^{b}
M. arvalis	RA	1.2, SE = 0.3	2.7, SE = 1.1	4.5, SE = 1.9	2.1, SE = 1.0	1.9, SE = 0.6	1.0, SE = 0.5	0.1
	% (CI)	27.7 ^{b} (24.2–31.5)	61.5 ^{a} (42.5–77.6)	71.7 ^{a} (64.7–77.7)	31.6 ^{b} (22.2–42.7)	23.1 ^{b} (19.2–27.5)	14.9 ^{c} (9.9–21.9)	1.5 ^{d} (0.3–7.9)
A. flavicollis	RA	2.0, SE = 0.4	0.8, SE = 0.4	0.2, SE = 0.2	1.86, SE = 0.8	1.2, SE = 0.4	1.9, SE = 0.7	3.7, SE = 2.6
	% (CI)	33.9 ^{a} (0.1–37.9)	19.2 ^{ab} (8.5–33.9)	3.3 ^{b} (1.5–7.1)	26.3 ^{a} (17.7–37.2)	20.6 ^{ab} (16.9–24.9)	32.1 ^{a} (24.8–40.4)	36.8 ^{a} (26.3–48.6)
A. agrarius	RA	1.1, SE = 0.5	0.8	1.6, SE = 1.2	2.4, SE = 1.1	2.0, SE = 0.6	1.6, SE = 0.9	3.7, SE = 1.7
	% (CI)	16.2 ^{b} (13.4–19.5)	19.2 ^{b} (8.5–33.9)	22.8 ^{a} (7.3–29.4)	36.4 ^{a} (26.9–48.1)	32.4 ^{a} (28.0–37.2)	23.9 ^{a} (17.4–31.8)	27.9 ^{a} (19.7–39.6)
C. glareolus	RA	1.2, SE = 0.4 ^{b}	–	0.05^{b}	–	0.5, SE = 0.2 ^{b}	1.3, SE = 0.6 ^{b}	4.9, SE = 1.7 ^{a}
	% (CI)	14.3 ^{b} (11.7–17.4)	–	0.6 ^{d} (0.1–3.1)	–	8.3 ^{c} (6.0–11.4)	20.9 ^{ab} (14.9–28.5)	30.9 ^{a} (21.2–42.6)

Maximal relative abundances of *M. arvalis* were registered in the currant plantations and mowed meadows, with 26.67 and 25.33 individuals per 100 trap-days, respectively. The maximum abundances of *A. flavicollis* and *A. agrarius* were in non-mowed meadow, 14.67 and 17.33 individuals per 100 trap-days, while those of *C. glareolus* were in apple orchards, 15.33 individuals per 100 trap-days.

The proportions of *M. arvalis* were highest in currant plantations and plum orchards, while the species proportion was negligible in the forest ecotone. The proportions of *A. flavicollis* were highest in the forest ecotones and apple orchards, significantly exceeding those in currant plantations, plum orchards, and mowed meadows. Apple and plum orchards were characterized by the lowest proportions of *A. agrarius*. The proportion of

C. glareolus was highest in the forest ecotones and non-mowed meadows, while the species was not present in plum orchards and raspberry plantations (Table 4).

4. Discussion

Often occurring in high abundances, small mammals, mostly rodents, may become pests of the agricultural landscape, and thus they can contribute to ecosystem disservices [52]. Regarding commercial fruit orchards and berry plantations, information relating to the small mammal communities that inhabit them is not comprehensive [31,32,34,36,39,42,45,53]. The current manuscript expands knowledge on the influence of crop type on the diversity and abundance of small mammals and their trends, which can be useful in appreciating the sustainability of orchards and their value for biodiversity [54–56] and how small mammals could be used as an indicator group [19].

Populations of small mammals in agrolandscapes are subjected to various forces of environmental and human origin, including disturbance via changes of habitat [57], agricultural activities [58], rodenticide treatment [59], crop type [60], and biological features of the species concerned [61]. Small scale factors such as predation and habitat structure [62,63] cannot be excluded from this list, but are rarely investigated.

Dynamics of small mammal abundances may be cyclic or erratic without regular fluctuations [64]. Rodent cycles are more characteristic to northern latitudes [65] and are related to the productivity of vegetation, predation, and other factors (e.g., [66]). In the recent years, due to mild winters, high amplitude vole cycles have been substituted with annual fluctuations [67]. In agricultural habitats, large outbreaks of rodent abundances can have major impacts on the economy, conservation, and human health ([64] and references therein). Therefore, the question of small mammal dynamics is a multifaceted issue. However, despite confirming between-year differences in the relative abundances of the dominant species in orchards, our time-series so far is too short for an evaluation of the cyclicity or outbreaks.

Our results show spatio-temporal variation in small mammal abundance, diversity, and proportions of the most abundant species in the commercial orchards, these being driven by season and medium-scale spatial differences, with dependence on the crop type being less expressed. From the three-year long study, we got also yearly differences, but according to [8], a very long time series might be required to confirm the observed trends. Small mammals might be indicators of the human influence on landscapes [19,37], but these species should occur in sufficient numbers.

We show that commercial orchards are suitable habitats for various granivore and herbivore species and may support high abundances. As a source of provided foods, represented by the trophic niches of species, orchards are different from "wild" or "natural" habitats in as much as they are scarce in seeds for granivores [43], this thus influencing competition for food in herbivores [44]. Habitat characteristics have only so far been analyzed in general in terms of age and crop type ([39] and this paper), though it is also possible that the structural diversity of vegetation may have an influence on diversity of small mammals in orchards and surrounding areas [53,68]. Small mammals are influenced by the structure of the crops [60], monocultures [28], management options and intensity [39,69], and the presence of refuges [53,70].

Only permanent crops are suitable for the prediction of small mammal community trends [60]. Commercial orchards, being a part of the agrolandscape, have already proved that they can support high numbers of species and small mammal diversity in several countries [31–37,39,53,59], and they are a good example of crop stability. In Lithuania, the diversity of small mammals in commercial orchards is higher than that in forest habitats [39]. Therefore, results of investigations into small mammals in orchards are useful not only in planning sustainable maintenance of these habitats, but they could also be an example of methodology for small mammal research in agroforestry [71].

5. Conclusions

1. In Lithuania, the proportions and relative abundances of the most numerous small mammal species and the diversity of their communities in commercial orchards mainly depend on the season and the region within the country, with crop type being less significant.
2. In comparison to the summer season, the relative abundance of *C. glareolus* doubled in autumn, while that of *M. arvalis* and *A. flavicollis* tripled and *A. agrarius* increased by nearly 15 times. Increases of relative abundance show potential of the orchard habitat to support diverse populations of small mammals belonging to different groups (omnivores, herbivores, and granivores).
3. The absence of significant year on year differences in the relative abundances of small mammals and the stability in the number of species allows us to conclude that orchards are an important source of biodiversity in the agricultural landscape.

Supplementary Materials: The following are available online at https://www.mdpi.com/article/10.3390/agriculture12050632/s1, Figure S1: Small mammal species accumulation curves and diversity in relation to trapping effort: (a)—diversity in orchards, (b)—number of species in orchards, (c)—diversity in control habitats, (d)—number of species in control habitats; Table S1: Season-based differences of analysed small mammal populations and species indices (RA—relative abundance ± SE, %—proportion of the species, 95% CI), data from 2018–2020 pooled.

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Institutional Review Board Statement: The study was conducted in accordance with Lithuanian (the Republic of Lithuania Law on the Welfare and Protection of Animals No. XI-2271, "Requirements for the Housing, Care and Use of Animals for Scientific and Educational Purposes", approved by Order No B1-866, 31/10/2012 of the Director of the State Food and Veterinary Service (Paragraph 4 of Article 16) and European legislation (Directive 2010/63/EU) on the protection of animals and approved by the Animal Welfare Committee of the Nature Research Centre, protocol No GGT-7. Snap trapping was justifiable as we studied reproduction parameters and collected tissues and internal organs for analysis of pathogens, elemental content and stable isotopes (not covered in this publication).

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