

Occurrence of the harvest mouse (*Micromys minutus*) and the hazel dormouse (*Muscardinus avellanarius*) in Slovakia based on summer nests (2013–2021)

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Abstract: The author states the occurrence of harvest mouse (*Micromys minutus* (Pallas, 1771)) and hazel dormouse (*Muscardinus avellanarius* (Linnaeus, 1758)) in the East Slovakia based on summer nests from field margins, hedgerows, and woodland edges. A total of 791 (551 *M. minutus* and 240 *M. avellanarius*) nests from 71 localities were observed over the years 2013–2021. The total elevation range of these sites was between 110 – 560 m a.s.l., with different ratio recorded for both species. For *M. minutus* 15 plant species and for *M. avellanarius* 16 plant species were confirmed, with different dominance of their use. A statistically significant difference was confirmed by Mann-Whitney U test comparing both species for two common plants i.e., *Prunus spinosa* L. (U = 866.0, p = 0.012) and *Rubus plicatus* Weihe & Nees (U = 1103.0, p < 0.0001). Moreover, Spearman's correlations confirmed significant relationships between the positions of nests and plant height. At the same time, 12 individuals of *M. minutus* and 8 individuals of *M. avellanarius* were confirmed dead or escaping directly from their nests. Analysis of the composition of the leaves in the *M. avellanarius* nests showed the following proportions. Leaves of the three species *R. plicatus* (66.2%), *Carpinus betulus* L. (14.5%), and *P. spinosa* (8.3%) were most common in mixed nests. For foliar nests, a ratio of two dominant species, *R. plicatus* (50.0%) and *C. betulus* (41.6%), was recorded. Finally, for the layered nests, a ratio of two dominant species, *R. plicatus* (50.0%) and *C. betulus* (33.3%) was recorded. The obtained data help spreading knowledge of both species in the territory of Slovakia.

Key words: summer nests, *Micromys minutus*, *Muscardinus avellanarius*, hedgerows, field margins, woodland edges, Slovakia, distribution

Introduction

Distribution of harvest mouse (*Micromys minutus* Pallas, 1771) was recorded in approximately 59.1% of the Slovak territory mainly in lowlands, highlands, and basins up to altitudes of 600–800 m a.s.l., sporadically also occurs at higher altitudes. Vertical distribution ranges from 97 m a.s.l. in the National Nature Reserve Tajba near Streda nad Bodrogom village in the Východoslovenská nížina plain to about 1,000 m a.s.l. under Minčol Mt. in the Čergov Mts, of 1,080–1,090 m a.s.l. in the National Nature Reserve Šimonka in the Slanské vrchy Mts. and 1,920 m a.s.l. under the Kopské sedlo Saddle under Hlúpy Mt. in the Belianske Tatry Mts. In Slovakia, the species lives first on banks of brooks, rivers, canals, near to standing water bodies, in reed stands, in wet meadows, in wind shelterbelts, in ruderals, in fields, orchards, vineyards. In autumn and winter, it lives in straw ricks. It often occurs in lowland type of floodplain, forests. In other type of forests, it occurs rarely, as well as in forest-steppe like dry habitats (Krištofik 2012).

On the other hand, occurrence of common dormouse (*Muscardinus avellanarius* Linnaeus, 1758) was recorded in about 53.2% of the Slovak territory, where is continuously distributed in submontane and mountain area. The mosaic-like occurrence in lowlands and basins results from a historically long-lasting deforestation and a strong fragmentation of habitats. It rarely occurs in inundated floodplain forest because of its hibernation in the ground. Therefore, it is endan-

gered by an increased level of groundwater table or by inundations. Its vertical distribution reaches from ca. 100 m a.s.l. (floodplain forests of the Bodrog and Latorica rivers) to 1.900 m a.s.l. (the Vysoké Tatry Mts.). However, its occurrence above 1.600 m a.s.l. is sporadic. Most records from Slovakia originate from altitudes of 200–800 m a.s.l. (Stanko & Mošanský 2012).

Several authors (Anděra 1994; Bence *et al.* 2003; Surmacki *et al.* 2005; Juškaitis & Remeisis 2007a, b; Juškaitis 2008; Hata 2011; Čanádý 2012, 2013, 2015) have confirmed that shrubby stands such as e.g., *Prunus spinosa* L., *Rubus plicatus* Weihe & Nees and *Carpinus betulus* L., were often used as a base for summer nest fixation by individuals of both species, the harvest mouse and hazel dormouse in field margins and forest edges, respectively. In these habitats, individuals not only build round nests above the ground, but also spend most of their lives in dense vegetation. Rarely, dormice nests have also been recorded on various herbs (Čanádý 2018). They use the nests for breeding as well as for resting during the day. However, most of these nests are temporary and destroyed, so individuals abandon them and build new ones during the breeding season. A more detailed literature review concerning not only faunistic and ecological studies of both species, but also the morphology of the nests themselves, not only in the Czech and Slovak Republics (former Czechoslovakia), but also from foreign provenance have been summarized in previous studies (Čanádý 2012, 2013, 2015).

The aim of the present study is to build on the previous faunistic overview of the occurrence of the above-mentioned species based on summer nests (see Čanádý 2012) and to contribute to the expansion of knowledge on the occurrence in Slovakia. Similarly, the type of nests as well as its botanical composition is discussed in more detail in the paper.

Material and Methods

The study presents data on the occurrence of summer nests of *M. minutus* and *M. avellanarius* obtained in 2013 – 2021 from 71 localities of seven orographic units (Košická kotlina basin, Čierna hora mountains, Šarišská vrchovina highland, Slanské vrchy mountains, Ondavská vrchovina highland, Laborecká vrchovina highland and Východoslovenská rovina lowland) of eastern Slovakia. The overview of individual localities and occurrence of nests is a continuation of the overview for 2010 – 2012 (cf. Čanádý 2012) and is primarily intended to complement the faunistic data on the distribution of the above species by indirect observations.

Nests were systematically searched by hand during checking field and forest edges and margins 1–1.5 m wide adjacent to forests (oak-beech, beech-hornbeam, hornbeam-elm, etc.) and shrub stands or to variously sized hedgerows and windbreaks. Vegetation in the alluvium of the Hornád, Ondava and Torysa rivers was also searched. These field margins were mostly formed by vegetation of several species of grasses and herbs (e.g., *Urtica dioica* L., *Solidago gigantea* Ait., *Phalaris arundinacea* L., *Tanacetum vulgare* L., *Elymus repens* (L.) Gould, *Carex* spp. L., and several species from the families Poaceae, Brassicaceae and Asteraceae, etc.) and the shrub component was mainly formed by species of *Prunus spinosa* L., *Rubus plicatus* Weihe & Nees, *R. idaeus* L., *Sambucus nigra* L., *Cornus sanguinea* L., *Crataegus monogyna* Jacq., *Rosa canina* L.). At the above-mentioned habitats i.e., in the marginal lines, a single field edge inspection was carried out in the autumn-winter months outside the breeding season and at the time of nest abandonment. Therefore, all nests found between January and April belong to the previous year (e.g., the nests found on 18.03.2016 were from the year 2015). In a few cases, records were also made during the breeding season, during butterfly surveys.

Nests of *M. minutus* were determined and distinguished from similar grassy nests of *M. avellanarius* according to the study by Wachtendorf (1951), who lists four basic types of hazel dormouse nests (cf. Juškaitis 2008; Čanádý 2012, 2013, 2015):

- a) **Mixed nests** are formed from the woven leaves of trees or shrubs together with the leaves of grasses. Tree leaves and grasses are intermixed in the nest walls.
- b) **Layered nests** have two distinct layers: an outer layer made usually from tree leaves and an inner layer made from fine material (grass, fibre). As a rule, adult females make layered nests for breeding.
- c) **Grassy nests** comprise a dense sphere of dry leaves (only seldom with stalks) of grasses and are characteristic of habitats with an obvious prevalence of coniferous trees.
- d) **Foliar nests** are plaited from dry or fresh leaves of trees or shrubs, although some grasses may be used as supplementary material.

Tab 1: List of summer nests found in different localities in the period 2013–2021.

Locality	GPS*	Altitude** (m a.s.l.)	Habitat type	Dimensions***	Σ <i>M. min.</i>	Σ <i>M. avell.</i>
Košická kotlina basin						
Belža (Line 1)	48°35'43"N, 21°16'12"E	183	field margin	1500x1.5	7	
Belža (Line 2)	48°35'07"N, 21°16'30"E	183	windbreak	1400x1.5		4
Bočiar (Line 1)	48°35'13"N, 21°14'11"E	202	field margin	1000x1.5	4	
Bočiar (Line 2)	48°35'03"N, 21°14'17"E	195	field margin	1400x1.5	7	
Bretejovce (Line 1)	48°50'03"N, 21°17'30"E	205	field margin	380x1.5	2	
Bretejovce (Line 2)	48°50'12"N, 21°17'54"E	206	windbreak	1100x1.5		1
Budimír	48°47'56"N, 21°17'09"E	270	hedgerow	2300x1.5	7	4
Čaňa (Line 1)	48°36'26"N, 21°18'03"E	179	field margin	2000x1.5	5	
Čaňa (Line 2)	48°36'27"N, 21°18'04"E	176	hedgerow	900x1.5	10	1
Drienov	48°36'27"N, 21°18'04"E	298	woodland edge	7400x1.5	11	9
Gyňov (Line 1)	48°35'06"N, 21°19'47"E	167	hedgerow	2095x1.5	21	3
Gyňov (Line 2)	48°35'18"N, 21°19'01"E	167	field margin	890x1.5	4	
Haniska pri Košiciach (Line 1)	48°37'00"N, 21°15'53"E	190	hedgerow	1000x1.5	9	
Haniska pri Košiciach (Line 2)	48°36'50"N, 21°16'45"E	190	hedgerow	660x1.5	1	
Haniska pri Košiciach (Line 3)	48°36'58"N, 21°16'28"E	190	hedgerow	1000x1.5	6	
Haniska pri Košiciach (Line 4)	48°35'45"N, 21°15'54"E	183	windbreak	1300x1.5	35	
Haniska pri Košiciach (Line 5)	48°35'55"N, 21°16'52"E	183	field margin	1900x1.5	39	
Haniska pri Prešove	48°56'45"N, 21°14'39"E	230	hedgerow	1500x1.5	23	7
Janovík	48°50'09"N, 21°17'34"E	205	field margin	200x1.5	5	
Kendice (Line 1)	48°56'19"N, 21°14'23"E	235	hedgerow	1000x1.5	38	
Kendice (Line 2)	48°56'19"N, 21°14'23"E	231	hedgerow	1200x1.5	26	
Kendice (Line 3)	48°56'12"N, 21°14'21"E	240	hedgerow	400x1.5	6	
Košice part Šebastovce (Line 1)	48°39'29"N, 21°15'47"E	207	hedgerow	2100x1.5	5	1
Košice part Šebastovce (Line 2)	48°39'17"N, 21°14'50"E	222	hedgerow	3840x1.5		2
Ličartovce (Line 3)	48°52'11"N, 21°15'07"E	215	field margin	240x1.5	6	
Milhost' (Line 1)	48°31'55"N, 21°16'19"E	158	field margin	580x1.5	2	
Milhost' (Line 2)	48°31'43"N, 21°16'24"E	156	field margin	1200x1.5	26	

Locality	GPS*	Altitude** (m a.s.l.)	Habitat type	Dimensions***	Σ <i>M. min.</i>	Σ <i>M. avell.</i>
Milhost' (Line 3)	48°32'00"N, 21°16'50"E	158	hedgerow	1400x1.5	8	
Obišovce (Line 1)	48°51'48"N, 21°15'21"E	214	field margin	2300x1.5	5	1
Petrovany (Line 1)	48°56'06"N, 21°15'33"E	226	road margin	550x1.5		1
Petrovany (Line 2)	48°56'12"N, 21°15'37"E	322	woodland edge	3150x1.5	3	7
Petrovany (Line 3)	48°56'09"N, 21°15'53"E	260	hedgerow	435x1.5		1
Petrovany (Line 4)	48°56'12"N, 21°15'37"E	227	hedgerows	500x1.5	4	9
Ploské	48°49'20"N, 21°20'21"E	240	hedgerow	2700x1.5	22	
Seniakovce (Line 1)	48°49'23"N, 21°17'57"E	208	field margin	2900x1.5	52	
Seniakovce (Line 2)	48°49'19"N, 21°17'46"E	216	hedgerow	1100x1.5	34	
Seňa	48°34'50"N, 21°14'15"E	203	hedgerow	1250x1.5	4	2
Sokoľany	48°35'52"N, 21°13'49"E	207	field margin	850x1.5	8	
Šemša (Line 1)	48°40'51"N, 21°07'17"E	350	woodland edge	2400x1.5	4	1
Trstené pri Hornáde (Line 1)	48°34'29"N, 21°21'18"E	254	hedgerow	490x1.5	5	
Trstené pri Hornáde (Line 2)	48°33'55"N, 21°22'06"E	298	woodland edge	4600x1.5	33	10
Trstené pri Hornáde (Line 3)	48°34'23"N, 21°19'37"E	170	field margin	1700x1.5	8	
Valaliky	48°38'46"N, 21°16'44"E	190	wetland	1500x1.5	3	
Ždaňa/Čaňa	48°36'30"N, 21°20'53"E	170	field margin	3000x1.5	18	3
Šarišská vrchovina highland						
Drienovská Nová Ves (Line 1)	48°53'23"N, 21°14'37"E	229	woodland edge	1500x1.5	4	4
Drienovská Nová Ves (Line 2)	48°53'20"N, 21°14'41"E	216	field margin	2000x1.5	1	
Kendice (Line 4)	48°56'24"N, 21°13'49"E	330	woodland edge	2000x1.5		2
Čierna hora Mts						
Lemešany – Chabžany	48°50'04"N, 21°15'38"E	370	hedgerow	2700x1.5	6	24
Ličartovce (Line 1)	48°53'11"N, 21°14'40"E	229	woodland edge	400x1.5	9	2
Ličartovce (Line 2)	48°53'14"N, 21°14'45"E	214	field margin	330x1.5	3	
Obišovce (Line 2)	48°52'02"N, 21°14'00"E	300	woodland edge	1400x1.5	1	2

Locality	GPS*	Altitude** (m a.s.l.)	Habitat type	Dimensions***	Σ <i>M. min.</i>	Σ <i>M. avell.</i>
Slanské vrchy Mts						
Podhradík	48°40'11"N, 21°07'22"E	350	hedgerow	2000x1.5		4
Ondavská vrchovina highland						
Belejovce	49°22'22"N, 21°31'51"E	560	woodland edge	2500x1.5		2
Breznica	49°09'40"N, 21°40'05"E	180	woodland edge	500x1.5		1
Brezníčka	49°13'50"N, 21°41'54"E	286	woodland edge	1100x1.5		3
Cernina	49°17'41"N, 21°28'53"E	360	woodland edge	500x1.5		3
Dubová	49°21'15"N, 21°27'24"E	290	woodland edge	1000x1.5		1
Duplín (Line 1)	49°14'08"N, 21°38'11"E	260	woodland edge	1000x1.5	1	16
Duplín (Line 2)	49°14'14"N, 21°38'03"E	197	hedgerow	400x1.5	1	1
Hrabovčík	49°17'06"N, 21°33'14"E	287	woodland edge	1000x1.5		4
Jakušovce	49°09'42"N, 21°45'31"E	433	woodland edge	800x1.5		1
Jurkova Voľa	49°19'25"N, 21°31'37"E	280	woodland edge	500x1.5	1	3
Korunková	49°12'36"N, 21°45'02"E	386	woodland edge	1500x1.5	2	
Kručov	49°06'57"N, 21°36'50"E	250	woodland edge	1000x1.5		1
Kurimka	49°19'31"N, 21°25'20"E	322	woodland edge	1000x1.5		1
Matovce	49°08'13"N, 21°33'16"E	260	woodland edge	2200x1.5		2
Mrázovce	49°06'23"N, 21°40'39"E	360	woodland edge	1500x1.5	1	6
Nižná Jedľová	49°19'41"N, 21°32'34"E	300	woodland edge	780x1.5		7
Nižná Pisaná	49°23'17"N, 21°35'07"E	415	woodland edge	3000x1.5		1
Nižný Mirošov	49°22'26"N, 21°28'11"E	318	woodland edge	1200x1.5		4
Ortuťová	49°16'37"N, 21°27'58"E	250	woodland edge	500x1.5		2
Piskorovce	49°06'06"N, 21°43'28"E	356	woodland edge	1000x1.5		5
Potoky	49°15'26"N, 21°37'52"E	400	woodland edge	2200x1.5	1	8
Regetovka	49°25'37"N, 21°16'18"E	560	woodland edge	1600x1.5		1
Rovné	49°17'03"N, 21°30'08"E	350	woodland edge	800x1.5		3
Solník	49°12'59"N, 21°44'47"E	340	woodland edge	1600x1.5	1	6

Locality	GPS*	Altitude** (m a.s.l.)	Habitat type	Dimensions***	Σ <i>M. min.</i>	Σ <i>M. avell.</i>
Ondavská vrchovina highland						
Šarišské Čierne	49°20'14"N, 21°23'13"E	424	woodland edge	1500x1.5		2
Tokajik	49°06'51"N, 21°42'18"E	250	woodland edge	1500x1.5	1	2
Valkovce	49°09'51"N, 21°32'32"E	246	woodland edge	1500x1.5		4
Veľkrop	49°14'38"N, 21°45'03"E	350	woodland edge	1500x1.5		3
Vojtovce	49°12'18"N, 21°41'14"E	278	woodland edge	500x1.5		5
Vyšná Olšava	49°10'08"N, 21°35'52"E	234	woodland edge	600x1.5	1	2
Vyšný Hrabovec	49°05'46"N, 21°40'51"E	240	woodland edge	800x1.5		1
Vyšný Mirošov	49°23'34"N, 21°26'32"E	400	woodland edge	1200x1.5		4
Vyšný Orlík	49°21'02"N, 21°29'26"E	280	woodland edge	1000x1.5		4
Zborov	49°21'00"N, 21°18'40"E	460	woodland edge	800x1.5		1
Laborecká vrchovina highland						
Bodružal	49°20'56"N, 21°42'44"E	387	woodland edge	1150x1.5		2
Korejovce	49°22'53"N, 21°38'21"E	380	woodland edge	800x1.5		4
Miková	49°18'34"N, 21°48'47"E	510	woodland edge	1200x1.5		2
Miroľa	49°20'04"N, 21°43'53"E	420	woodland edge	850x1.5	1	5
Nižný Komárnik	49°22'35"N, 21°41'28"E	409	woodland edge	1100x1.5		2
Pstriná	49°18'07"N, 21°44'56"E	450	woodland edge	1600x1.5		3
Staškovce	49°15'52"N, 21°44'39"E	280	woodland edge	1000x1.5		1
Šarbov	49°25'18"N, 21°37'52"E	433	woodland edge	1200x1.5		1
Vyšná Pisaná	49°22'02"N, 21°36'25"E	455	woodland edge	800x1.5		1
Východoslovenská rovina upland						
Nižný Hrušov	48°47'16"N, 21°46'05"E	110	hedgerow	2000x1.5		1
Rakovce and Ondavou	48°45'19"N, 21°45'28"E	110	hedgerow	1200x1.5		1
Total					551	240

Note:

* GPS coordinates listed here show the location of the line being checked, usually in the middle of the line,

** highest altitude in the line,

*** length x width of line.

According to the findings of several authors (Májský & Filípek 2007; Juškaitis 2008; etc.), precise identification is very problematic and cannot rely solely on the composition of the building material. Therefore, the overall appearance and character of the surrounding habitat, as well as the presence of droppings, were also considered during the determination.

As in the previous study (cf. Čanády 2012), only clearly identified nests were included in further research and were excluded in case of uncertain identification. A total of 791 nests (551 nests of *M. minutus* and 240 nests of *M. avellanarius*) were recorded (Fig. 1). In addition to site data, nest metrics were also collected, as well as their placement on the surrounding vegetation. Only the placement of nests from the ground was evaluated and included in this study. At the same time, the presence of individuals in the vicinity or directly on the nests was also recorded (Fig. 2), which were documented photographically, or a short video recording was made.

In the following overview, the locations of nests found in individual orographic units are listed with the GPS coordinates, dimensions (length and width of line), the highest altitude in the given line (edge) of the woodland edge, field margin or hedgerow (Tab. 1).

Differences between placement of nests were evaluated by unparametric Mann-Whitney U test. The relationships among plant height and placement (position) of nests were also explored with Spearman's correlation analyses. All analyses were performed using MS Excel 2003 for Windows XP and the statistical analysis system GraphPad Prism, version 5.01 (GraphPad Software, Inc., San Diego, California, USA).

Result and Discussion

Totally, 551 nests of harvest mice and 240 nests of hazel dormice were recorded during the monitoring period (Tab. 1, Fig. 1). In addition to nests, individuals were observed on several occasions either directly in nests or individuals that escaped during nest searches (Fig. 2). It should be stressed that despite the higher number of nests at the above sites, it is not possible to fully determine the density of the species, as a single individual of *M. avellanarius* (as well as *M. minutus*) may use several nests in its home range (cf. Juškaitis 2008). This was especially true when multiple nests were found within a radius of a several centimetres to 2 metres.



Fig 1: Nests of the harvest mouse *Micromys minutus* (Pallas, 1771) (1 – 2) and hazel dormouse, *Muscardinus avellanarius* (Linnaeus, 1758) (3 – 4) in studied areas of south-eastern Slovakia. **1, 2** – *Micromys minutus* (Trstené pri Hornáde village, 08.I.2022), **3** – *M. avellanarius* (Jakušovce village, 24.VII.2013), **4** – *M. avellanarius* (Piskorovce village, 08.X.2015).



Fig 2: The individuals of the *Muscardinus avellanarius* (Pallas, 1771) (1 – 2) and *Micromys minutus* (Linnaeus, 1758) (3 – 4) in studied area of SE Slovakia. **1** – *M. avellanarius* (Vojtovce village, 09.X.2015), **2** – *M. avellanarius* (Jakušovce village, 24.VII.2013), **3** – *Micromys minutus* (Trstené pri Hornáde village, 08.I.2022), **4** – *Micromys minutus* (Seniakovce village, 09.II.2022).

According to the placement of nests on vegetation, differences were found for both species (Tab. 2, 3). For *M. minutus* 15 species and for *M. avellanarius* 16 species were confirmed, with different dominance of their use. A statistically significant difference was confirmed by Mann-Whitney U test comparing both species for two common plants i.e., *P. spinosa* ($U = 866.0$, $p = 0.012$) and *R. plicatus* ($U = 1103.0$, $p < 0.0001$).

Moreover, Spearman correlations were used to test for significant correlations between the positions of nests and plant height. Analyses between the distance of the *M. minutus* nests from the ground and plant height, confirmed positive correlations (except for *Carex* spp.) regardless of the plant species used for nesting: *E. repens* ($n = 209$, $r_s = 0.32$, $p < 0.0001$), *P. arundinacea* ($n = 164$, $r_s = 0.21$, $p = 0.006$), *R. plicatus* ($n = 64$, $r_s = 0.51$, $p < 0.0001$), *P. spinosa* ($n = 26$, $r_s = 0.42$, $p = 0.035$), and *Carex* spp. ($n = 18$, $r = 0.26$, $p = 0.29$).

For position of *M. avellanarius* nests were confirmed positive correlations (except for *C. betulus*): *P. spinosa* ($n = 98$, $r_s = 0.49$, $p < 0.0001$), *R. plicatus* ($n = 79$, $r_s = 0.80$, $p < 0.0001$), *C. sanguinea* ($n = 20$, $r_s = 0.69$, $p = 0.0007$), and *C. betulus* ($n = 9$, $r_s = 0.62$, $p = 0.076$).

Four nest types also were confirmed in *M. avellanarius*, with a marked dominance of mixed nests (tab. 4). These findings are also consistent with previous findings (cf. Juškaitis 2008; Čanády 2012, 2015). The authors reported mixed type nest as the most frequently occurring nest type in Lithuania and Slovakia. The remaining three nest types were recorded much less. It was also shown that the proportion of leaves of each plant species in three type nests depends on their presence as well as abundance in the immediate vicinity (Juškaitis 2008; Čanády 2015).

Analysis of the composition of the leaves in nests found between 2013 – 2021, the showed following proportions. Leaves of the three species *R. plicatus* (66.2%), *C. betulus* (14.5%), and

P. spinosa (8.3%) were most common in mixed nests. For foliar nests, a ratio of two dominant species, *R. plicatus* (50.0%) and *C. betulus* (41.6%), was recorded. Finally, for the layered nests, a ratio of two dominant species, *R. plicatus* (50.0%) and *C. betulus* (33.3%) was recorded.

The total elevation range of 71 localities (for *M. minutus* 53 lines, and for *M. avellanarius* 68 lines) was between 110 – 560 m a.s.l., with the following ratio recorded for both species (Tab. 5). These findings were also in agreement with occurrence data at different altitudes summarized by several authors (e.g., Anděra 1987, 1994; Anděra & Beneš 2001; Mošanský 1993; Mošanský *et al.* 1998; Čanády 2012).

The harvest mouse (*M. minutus*) inhabits a wide range of open habitats such as reedbeds, wet meadows, river, and pond banks as well as other wetland areas overgrown with dense vegetation. The occurrence of the species has also been confirmed in windbreaks and field habitats, gardens, orchards, and cemeteries etc. In these habitats, individuals spend majority of their lives in dense vegetation, where they build round nests located above the ground. They use the nests for breeding as well as for resting during the day. Most of these nests, however, are temporary and destroyed, so individuals leave them and build new ones during the breeding season (Anděra 1987, 1994; Bence *et al.* 2003; Surmacki *et al.* 2005; Juškaitis & Remeisis 2007a, b; Juškaitis 2008; Hata 2011; Čanády 2012, 2013, 2015). Females may also use several nests for rearing juveniles between May and October (Anděra & Beneš 2002 etc.).

Tab 2: List of summer nests found on vegetation in the period 2013–2021.

	<i>M. minutus</i> N (%)	<i>M. avellanarius</i> N (%)
<i>Acer campestre</i> L.	1 (0.2)	1 (0.4)
<i>Artemisia vulgaris</i> L.		1 (0.4)
<i>Carex</i> spp.	20 (3.6)	
<i>Carpinus betulus</i> L.		10 (4.2)
<i>Cirsium arvense</i> (L.) Scop.		1 (0.4)
<i>Cornus sanguinea</i> L.	8 (1.5)	20 (8.3)
<i>Elymus repens</i> (L.) Gould	225 (40.8)	
<i>Euonymus europaeus</i> L.	2 (0.4)	
<i>Fagus sylvatica</i> L.		1 (0.4)
<i>Galium verum</i> L.	3 (0.5)	
<i>Petasites hybridus</i> (L.) Gaertn., Mey. & Scherb.		2 (0.8)
<i>Phalaris arundinacea</i> L.	168 (30.5)	
<i>Phragmites australis</i> (Cav.) Trin. ex Steud.	2 (0.4)	
<i>Populus tremula</i> L.		1 (0.4)
<i>Prunus spinosa</i> L.	26 (4.7)	105 (43.8)
<i>Quercus</i> spp.		1 (0.4)
<i>Rubus plicatus</i> Weihe & Nees	66 (11.9)	81 (33.8)
<i>Rubus idaeus</i> L.		6 (2.5)
<i>Rosa canina</i> L.	2 (0.4)	1 (0.4)
<i>Setaria</i> spp.	7 (1.3)	
<i>Solidago gigantea</i> Aiton	11 (2.0)	3 (1.3)
<i>Urtica dioica</i> L.	1 (0.2)	1 (0.4)
unknow	1 (0.2)	1 (0.4)
on ground	8 (1.5)	4 (1.7)
Total	551	240

Tab 3: Placement of nests for *M. minutus* and *M. avellanarius* on vegetation for the most dominant vegetation species during years 2013 – 2021.

		N	Range	M±SD
<i>M. minutus</i>	<i>E. repens</i>	211	10.0–75.0	32.85±11.78
	<i>P. arundinacea</i>	164	10.0–110.0	44.87±16.63
	<i>R. plicatus</i>	64	15.0–85.0	38.66±13.92
	<i>P. spinosa</i>	26	30.0–110.0	53.50±18.17
	<i>Carex</i> spp.	18	30.0–75.0	48.61±14.83
<i>M. avellanarius</i>	<i>P. spinosa</i>	98	30.0–200.0	72.03±33.94
	<i>R. plicatus</i>	79	20.0–130.0	60.27±23.79
	<i>C. sanguinea</i>	20	20.0–130.0	47.65±25.37
	<i>C. betulus</i>	9	40.0–150.0	82.22±35.28

Tab 4: Frequency of occurrence of different nest types of *M. avellanarius* during years 2013 – 2021.

Nest type	Total	%
Mixed	145	60.4
Foliar	12	5.0.0
Grassy	71	29.6
Layered	12	5.0
Total	240	

Tab 5: Frequency of nests by altitude for *M. minutus* (N = 53 lines) and *M. avellanarius* (N = 68 lines) during years 2013 – 2021.

Altitude (m a.s.l.)	<i>M. minutus</i>		<i>M. avellanarius</i>	
	N	%	N	%
< 200	17	32.0	8	11.8
201 – 300	28	52.8	31	45.6
301 – 400	7	13.2	17	25.0
401 – 500	1	1.9	9	13.2
> 501			3	4.4

Moreover, in addition to a wide range of habitats, the great diversity of plants used for nest construction and their placement was confirmed (Spitzenberger & Bauer 2000; Anděra & Beneš 2002, Bence *et al.* 2003; Surmacki *et al.* 2005; Juškaitis & Remeisis 2007a, Hata 2011; Čanádý 2012, 2013, 2015).

In wet habitat types, harvest mice use mainly mesophilous vegetation such as *Phragmites australis* plants to anchor their nests, *Typha latifolia*, *Carex* spp., and others. On the contrary, scrub plants, especially *Rubus plicatus*, *Crataegus monogyna*, and *Prunus spinosa* were found as the main plants for nest location in field margins. Nevertheless, there is still very little knowledge on the use of field habitats by the field mouse. Bence *et al.* (2003) showed that field margins and windbreaks are only mowed every two to three years to remove scrub encroachment. The quality of these habitats therefore plays an important role in the survival of individuals into the next growing season, as mowing of margins just after harvest coincides with the peak of the breeding season.

On contrary, the hazel dormouse (*M. avellanarius*), is a typical inhabitant of deciduous and mixed forests. At the same time, it has the widest ecological valence among our dormice, with a variety of habitats such as different types of forests and coppice, in field margins, gardens and even in parks and woodlots close to larger agglomerations. Especially ecotonal sites with scattered rowan, hawthorn, hazel, and other berries (e.g., raspberry and blackberry) whose

presence increases the species density are favourite habitats (Anděra & Beneš 2001; Juškaitis & Remeisis 2007b; Juškaitis 2008; Čanády 2012, 2013, 2015; Feber *et al.* 2019).

Older and new literature sources concerning the distribution of the hazel dormice and harvest mice from Slovakia were summarized by (Stanko & Mošanský 2012; Krištofik 2012). Nevertheless, knowledge of the distribution in some areas of north-eastern Slovakia (e.g., Laborecká vrchovina highland, Ondavská vrchovina highland, Beskydské predhorie mountain, etc.) is still insufficient or completely absent (Čanády 2012, 2013).

Finally, it should be concluded that observations of more nests in shrubby vegetation of field margins, hedgerows and woodland edges confirmed that this micro-habitat may play an important role for suitable nesting of the harvest mouse and hazel dormouse. Moreover, data on the presence or absence of summer nests in the monitored habitat spread our knowledge about distribution of both species.

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Appendix

Overview of nests by dates and locations

Micromys minutus (551 nests (nes.) and 12 individuals)

Košická kotlina basin

- Belža: 10.02.2022 (Line 1: 7 nes. on *E. repens*, and *Carex* spp.).
- Bočiar: 13.2.2022 (Line 1: 4 nes. on *P. spinosa*, *P. arundinacea*, and *E. repens*; Line 2: 7 nes. on *P. spinosa*, *P. arundinacea*, *E. repens*, and fallen in the vegetation).
- Bretejovce: 22.02.2022 (Line 1: 2 nes. on *P. arundinacea*, *E. repens*, and *S. gigantea*).
- Budimír: 12.01.2022 (7 nes. on *R. plicatus*, *P. arundinacea*, and *E. repens*).
- Čaňa: 06.03.2022 (Line 1: 5 nes. on *P. arundinacea*, and *E. repens*; Line 2: 10 nes. on *R. plicatus*, *P. arundinacea*, *E. repens*, and fallen in the vegetation).
- Drienov: 18.03.2022 (11 nes. on *P. spinosa*, *C. sanguinea*, *P. arundinacea*, and *E. repens*; with 1 ex. (skull and skeleton) of *M. minutus* in one nest).
- Gyňov: 20.03.2022 (Line 1: (the Hornád river alluvium) 21 nes. on *R. plicatus*, *P. arundinacea*, *E. repens*, and fallen in the vegetation; Line 2: 4 nes. on *P. arundinacea*, and *E. repens*).
- Haniska pri Košiciach: 23.01.2022 (Line 1: 9 nes. on *P. arundinacea*, *S. gigantea*, and *E. repens*, and fallen in the vegetation; Line 2: 1 nes. on *P. arundinacea*; Line 3: 6 nes. on *P. arundinacea*, *P. australis*, and *S. gigantea*); 30.01.2022 (Line 4: 35 nes. on *Euonymus europaeus*, *P. spinosa*, *R. canina*, and *E. repens*; Line 5: 39 on *P. arundinacea*, *S. gigantea*, *E. repens*, and *Carex* spp.).
- Haniska pri Prešove: 13.01.2022 (23 nes. on *P. arundinacea*, *S. gigantea*, and *R. plicatus*).
- Janovík: 22.02.2022 (5 nes. on *P. arundinacea*, *E. repens*, and *Setaria* spp.).
- Kendice: 25.01.2022 (Line 1: 38 nes. on *P. spinosa*, *R. plicatus*, *P. arundinacea*, *S. gigantea*, *Gallium verum*, and *E. repens*; Line 2: 26 nes. on *R. plicatus*, *P. arundinacea*, and *E. repens*; Line 3: 6 nes. on *R. plicatus*, and *P. arundinacea*).
- Košice part Šebastovce: 19.01.2022 (Line 1: 5 nes. on *R. plicatus*, and *P. arundinacea*).
- Ličartovce: 11.03.2022 (Line 3: 6 nes. on *E. repens*, and *P. arundinacea*).
- Milhošť: 27.01.2022 (Line 1 (the Sokolianský potok brook alluvium): 2 nes. on *P. arundinacea*, and *Carex* spp.; Line 2 (the Belžianský potok brook alluvium): 26 nes. on *P. arundinacea*, and *Carex* spp.; Line 3: 8 nes. on *R. plicatus*, *P. arundinacea*, and *E. repens*).
- Obišovce: 11.03.2022 (Line 1: 5 nes. on *E. repens*, *E. europaeus*, *S. gigantea*, and *P. arundinacea*).
- Petrovany: 15.03.2022 (Line 2: 3 nes. on *E. repens*, and *P. arundinacea*; Line 4: 4 nes. on *R. canina*, and *C. sanguinea*).
- Ploské: 25.03.2022 (22 nes. on *P. spinosa*, *R. plicatus*, *P. arundinacea*, *S. gigantea*, and *E. repens*).
- Seniakovce: 09.02.2022 (Line 1: 52 nes. on *P. spinosa*, *R. plicatus*, *E. repens*, and *Setaria* spp. with 2 ex. juvenile individuals of *M. minutus* in one nest (fig. 2); Line 2: 34 nes. on *P. spinosa*, *R. plicatus*, *P. arundinacea*, and *E. repens*).
- Seňa: 13.02.2022 (4 nes. on *P. spinosa*).
- Sokolany: 06.03.2022 (8 nes. on *R. plicatus*, *E. repens*, and fallen in the vegetation).
- Šemša: 05.10.2013 (Line 1: 3 nes. on *P. australis*); 04.07.2014 (1 nes. on *P. australis*).

Trstené pri Hornáde: 07.01.2022 (*Line 1*: 5 nes. on *E. repens*); 08.01.2022 (*Line 3* (the Hornád river alluvium): 33 nes. on *P. arundinacea*, *R. plicatus*, and *E. repens* with 6 ex. juvenile individuals of *M. minutus* dead in the one nest (fig. 2); 12.01.2022 (*Line 3*: 8 nes. on *P. spinosa*, *P. arundinacea*, *U. dioica*, and *E. repens*).

Valalíky: 23.02.2022 (3 nes. on *P. arundinacea*, and *C. sanguinea*).

Ždaňa/Čaňa: 15.01.2022 (*Line 1* (the Hornád river alluvium): 18 nes. on *P. arundinacea*, *R. plicatus*, *S. sanguinea*, *E. repens*, and *Carex* spp.).

Čierna hora mountains

Drienovská Nová Ves: 10.03.2022 (*Line 1*: 4 nes. on *E. repens*, and *R. plicatus*; *Line 2*: 1 nes. on *E. repens*).

Lemešany – part Chabžany: 18.10.2019 (3 nes. on *E. repens*, and *A. campestre*); 10.01.2022 (3 nes. on *P. arundinacea*).

Ličartovce: 10.03.2022 (*Line 1*: 9 nes. on *P. arundinacea*, and *E. repens*; *Line 2*: 3 nes. on *Carex* spp.).

Obišovce: 08.10.2019 (*Line 2*: 1 nes. on *P. spinosa*).

Ondavská vrchovina highland

Duplín: 26.10.2013 (*Line 1*: 1 nes. on *P. spinosa*); 22.09.2019 (*Line 2* (the Ondava river alluvium): 1 nes. fallen on the ground after mowing).

Jurková Voľa: 24.11.2017 (1 nes. on *E. repens* with 1 ex. subadult individual of *M. minutus* dead in the nest).

Korunková: 10.10.2015 (2 nes. on *R. plicatus*, and *P. spinosa*, from one nest jumped out one individual at 14:05 hour).

Mrázovce: 24.10.2013 (1 nes. on *P. spinosa* with 2 ex. subadult individuals of *M. minutus* dead in the nest).

Potoky: 25.10.2013 (1 nes. on *P. spinosa*).

Solník: 18.10.2017 (1 nes. on *P. spinosa*).

Tokajik: 22.08.2013 (1 nes. on *R. plicatus*).

Vyšná Olšava: 02.11.2015 (1 nes. on *E. repens*).

Laborecká vrchovina highland

Miroľa: 09.10.2014 (1 nes. on *E. repens*).

***Muscardinus avellanarius* (240 nests and 8 individuals):**

Košická kotlina basin

Belža: 10.02.2022 (*Line 2*: 4 nes. on *R. plicatus*, and *P. spinosa*).

Bretejovce: 22.02.2022 (*Line 2*: 1 nes. on *P. tremula*).

Budimír: 12.01.2022 (4 nes. on *P. spinosa*).

Čaňa: 06.03.2022 (*Line 2*: 1 nes. on *R. plicatus*).

Drienov: 18.03.2022 (9 nes. on *P. spinosa*, and *C. sanguinea*).

Gyňov: 20.03.2022 (*Line 1*: (the Hornád river alluvium) 3 nes. on *R. plicatus*, and *P. spinosa*).

Haniska pri Prešove: 06.11.2018 (4 nes. on *R. plicatus* and *S. gigantea*); 13.01.2022 (3 nes. on *R. plicatus* and *C. sanguinea*).

Košice part Šebastovce: 19.01.2022 (*Line 1*: 1 nes. on an unspecified plant; *Line 2*: 2 nes. on *C. sanguinea*).

Obišovce: 11.03.2022 (*Line 1*: 1 nes. on *R. plicatus*).

Petrovany: 15.03.2022 (*Line 1*: 1 nes. on *R. plicatus*; *Line 2*: 7 nes. on *S. gigantea*, *P. spinosa*, and *C. sanguinea* with 1 ex. (skull and skeleton) of *M. avellanarius* in one nest; *Line 3*: 1 nes. on *C. sanguinea*; *Line 4*: 9 nes. on *P. spinosa*, *R. plicatus*, and *C. sanguinea*).

Seňa: 13.02.2022 (2 nes. on *P. spinosa*).

Šemša: 05.10.2013 (1 nes. on *C. betulus*).

Trstené pri Hornáde: 07.01.2022 (*Line 2*: 10 nes. on *P. spinosa*, and *R. plicatus*).

Ždaňa/Čaňa: 15.01.2022 (*Line 1* (the Hornád river alluvium): 3 nes. on *R. plicatus*).

Šarišská vrchovina highland

Drienovská Nová Ves: 11.03.2022 (*Line 2*: 2 nes. on *C. sanguinea*, and *P. spinosa*).

Kendice: 27.04.2018 (*Line 4*: 1 nes. on *C. betulus*); 18.09.2018 (*Line 4*: 1 nes. on *P. spinosa*).

Čierna hora mountains

Drienovská Nová Ves: 10.03.2022 (*Line 1*: 4 nes. on *R. plicatus*, a fallen on the ground bellow the *P. spinosa*).

Lemešany – part Chabžany: 09.04.2021 (1 nes. on *R. plicatus*); 10.01.2022 (23 nes. on *R. plicatus*, *P. spinosa* and *C. sanguinea*).

Ličartovce: 10.03.2022 (*Line 1*: 1 nes. on *R. plicatus*).

Obišovce: 08.10.2019 (*Line 2*: 2 nes. *R. plicatus* and *P. spinosa*).

Slanské vrchy mountains

Podhradík: 23.04.2016 (4 nes. on *P. spinosa*).

Ondavská vrchovina highland

Belejovce: 18.03.2016 (2 nes. on *R. plicatus*).
Breznica: 02.11.2015 (1 nes. on *P. spinosa*).
Breznička: 09.10.2015 (3 nes. on *P. spinosa*, and *R. plicatus*).
Cernina: 20.10.2017 (3 nes. on *P. spinosa*).
Dubová: 24.11.2017 (1 nes. on *P. spinosa*).
Duplín: 01.06.2013 (*Line 1*: 4 nes. on *R. plicatus*, and *P. officinalis*); 24.08.2013 (*Line 1*: 2 nes. on *P. spinosa*, and *C. arvensis*); 26.10.2013 (*Line 1*: 9 nes. on *R. plicatus*, and *P. spinosa*); 03.07.2015 (*Line 1*: 1 nes. on *R. ideas*); 10.06.2017 (*Line 2* (the Ondava river alluvium): 1 nes. on *P. officinalis*, with 1 ex. individual of *M. avellanarius* escaped from the nest at 15:25 hour, cf. Csanády 2018).
Hrabovčik: 20.10.2017 (4 nes. on *P. spinosa*).
Jakušovce: 24.07.2013 (1 nes. on *F. sylvatica*, with 2 ex. subadult individuals of *M. avellanarius* in nest, Fig. 1).
Jurková Voľa: 24.11.2017 (3 nes. on *C. betulus*, and *P. spinosa*).
Kručov: 19.11.2016 (1 nes. on *P. spinosa*).
Kurimka: 20.10.2017 (1 nes. on *Artemisia vulgaris*).
Matovce: 19.11.2016 (2 nes. on *P. spinosa*).
Mrázovce: 27.09.2013 (2 nes. on *R. plicatus*); 24.10.2013 (4 nes. on *C. betulus*, and *R. plicatus*, with 1 ex. individual of *M. avellanarius* escaped from the one nest).
Nižná Jedľová: 18.03.2016 (7 nes. on *R. plicatus*, *R. ideas*, *P. spinosa*, and *C. betulus*).
Nižná Pisaná: 19.03.2016 (1 nes. on *P. spinosa*).
Nižný Mirošov: 24.11.2017 (1 nes. on *P. spinosa*), 25.11.2017 (3 nes. on *R. plicatus*, and *P. spinosa*).
Ortuťová: 05.04.2017 (2 nes. on *R. plicatus*).
Piskorovce: 08.10.2015 (5 nes. on *P. spinosa*, and *R. ideas*).
Potoky: 25.10.2013 (7 nes. on *R. plicatus*, and *P. spinosa*); 11.7.2014 (1 nes. on *C. betulus*).
Regetovka: 21.09.2019 (1 nes. on *P. spinosa*).
Rovné: 20.10.2017 (3 nes. on *P. spinosa*, with 1 ex. individual of *M. avellanarius* escaped from the one nest).
Sofník: 10.10.2015 (2 nes. on *R. plicatus*); 20.11.2016 (2 nes. on *P. spinosa* and *R. plicatus*); 18.10.2017 (2 nes. on *R. plicatus*).
Šarišské Čierné: 20.10.2017 (2 nes. on *P. spinosa*).
Tokajik: 22.08.2013 (1 nes. on *P. spinosa*); 31.10.2015 (1 nes. on *R. ideas*).
Valkovce: 19.11.2016 (4 nes. on *P. spinosa*, and *R. plicatus*).
Veľkrop: 09.10.2015 (3 nes. on *R. plicatus*, and *P. spinosa*).
Vojtovce: 09.10.2015 (5 nes. on *R. plicatus*, with 1 ex. individual of *M. avellanarius* observed 1 m from the mixed-type nest at 13:00 hour, photo and video record, fig. 2).
Vyšná Olšava: 02.11.2015 (2 nes. on *P. spinosa*).
Vyšný Hrabovec: 31.10.2015 (1 nes. on *P. spinosa*).
Vyšný Mirošov: 25.11.2017 (4 nes. on *P. spinosa*, *R. plicatus*, and *R. canina*).
Vyšný Orlík: 24.11.2017 (4 nes. on *P. spinosa*, and *R. plicatus*).
Zborov: 07.08.2014 (1 nes. on *Q. petraea*).

Laborecká vrchovina highland

Bodružal: 09.10.2014 (1 nes. on *P. spinosa*); 30.10.2015 (1 nes. on *P. spinosa*, with 1 ex. subadult individual of *M. avellanarius* escaped from the nest at 13:00 hour).
Korejovce: 19.10.2017 (4 nes. on *R. plicatus*, and *P. spinosa*).
Miková: 10.10.2014 (2 nes. on *R. plicatus*, and *R. ideas*).
Miroľa: 09.10.2014 (2 nes. on *P. spinosa*); 16.04.2015 (2 nes. on *P. spinosa*); 30.10.2015 (1 nes. on *P. spinosa*).
Nižný Komárnik: 30.10.2015 (2 nes. on *P. spinosa*, and *R. plicatus*).
Pstriná: 09.10.2014 (3 nes. on *C. betulus*, and *P. spinosa*).
Staškovce: 10.10.2014 (1 nes. on *R. plicatus*).
Šarbov: 19.10.2017 (1 nes. on *R. plicatus*).
Vyšná Pisaná: 19.03.2016 (1 nes. on *C. betulus*).

Východoslovenská rovina upland

Nižný Hrušov: 10.03.2017 (1 nes. on *P. spinosa*).
Rakovce nad Ondavou: 10.03.2017 (1 nes. on *P. spinosa*).

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