



Synanthropic spider fauna of the Carpathian Basin in the last three decades

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Abstract

This paper reviews the scientific literature published on synanthropic spiders in three Carpathian Basin countries—Hungary, Slovakia and Romania. A total number of 204 spider species have been reported from human constructions. Most of the 204 spider species (165 species) found in buildings were only occasional visitors, so-called asynanthropic species with typically low abundance. On average, eusynanthropic (23 species) and hemisynanthropic (16 species) species accounted for 80% of the specimen number. We have discovered that the number of hemisynanthropic faunal elements have remained unchanged in the past three decades. At the same time 14 new eusynanthropic species have been observed in the region, roughly one new species in every 2 years. Some of them have been introduced from the tropics, but some species originates from southern Europe, which may be related to climate change. This hypothesis was also confirmed by the seasonal summer outdoor appearance of these eusynanthropic species. True tropical spiders could only be settled permanently in greenhouses with special climate (such as botanical gardens). We still do not have data of any synanthropic species posing a health risk in this region.

Keywords Introduction · Establishment · Climate change · Eusynanthropic · Hemisynanthropic · Asynanthropic

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Introduction

One of the most typical examples of man-made and constantly influenced environments is our narrower living habitat, our buildings of various purposes. Our constructed environment is spontaneously inhabited by several groups of animals; one of the most typical of them are spiders. In human evolution, spiders were among the first ones to be found in our narrower living environment and they are still present even in the most modern buildings of the 21st century. Three significant environmental conditions—specific climate, habitat structure and prey—are presenting a habitat/niche characteristic to man-made constructions, so it is not surprising that the fauna of buildings is also specific. The spider fauna of anthropogenic environments has been studied for a relatively long period of time. In Europe, outstanding pioneering works was published by Valešová (1966) and Sacher (1983) defining both the categories of synanthropisation and occurrence data.

Out of recent European works, an outstanding Polish study highlights the rapid change in the synanthropic fauna and the rapid spread of some eusynanthropic species (Rozwałka et al. 2013). Other studies, by Savory (1957), Platen (1984), and Salz (1992) also explored the spider fauna

of large European cities, including building-dwelling species. Numerous investigations have been carried out in Central Europe and also in the three countries of the Carpathian Basin where our study took place. Some of them dealt with some selected cities or specific man-made environments (such as botanical gardens) or reported the appearance of some new species. So far, there has been little work done on a larger geographical or time scale.

Szinetár (1992) published the first work in Hungary dealing exclusively with spiders living in man-made environments. It was based primarily on the survey of settlements in Transdanubia. This study reported several species that were newly detected in other European countries at that time (e.g. *Pseudeuophrys lanigera* (Simon, 1871), *Psilochorus simoni* (Berland, 1911), *Uloborus plumipes* (Lucas, 1846)) (Heimer and Nentwig 1991; Klein et al. 1995).

This was followed by research concentrating on a narrower landscape (Szinetár et al. 1999) and targeting the biology of a single building-dwelling species (Kovács et al. 2006, 2008; Kovács and Szinetár 2012, 2014, 2016, 2018). New species were also reported (Kovács and Szinetár 2004; Szinetár et al. 2014). So far, comprehensive work covering the whole territory of Hungary has not been completed.

The most detailed Central European research has been carried out recently, based on data from Slovakia (Gajdoš et al. 2018). This work provided a detailed overview of earlier studies concerning the residential spider fauna in more than 260 settlements in Slovakia (Gajdoš et al. in preparation). In the last two decades, several publications have dealt with synanthropic species newly introduced into Slovakia (Pekár and Gajdoš, 2001; Šestáková and Gajdoš, 2011). More recently, several species of subtropical and tropical origin have been found in botanical gardens in Slovakia (e.g. *Uloborus plumipes* Lucas, 1846, *Coleosoma floridanum* Banks, 1900, *Scytodes fusca* Walckenaer, 1837) (Suvák 2013; Šestáková et al. 2013, 2014, 2017).

In Romania, very few studies have been published on building-dwelling spiders. Urák (2005, 2007) reported on several alien and invasive building-dweller spiders in the fauna of Transylvania. A preliminary survey specifically aimed at building occupants was conducted in Cluj-Napoca (Párdi and Urák 2009). In a follow-up to this study, a total of 98 species were detected in 130 flats in Cluj-Napoca (block of flats or detached house) during a 1-year intensive collection (Párdi and Urák 2010). Some synanthropic spider species were identified for the first time in Romanian arachnofauna and the others for the second time (Párdi 2009).

In the current study, we aim to answer the following questions in three neighbouring Central European countries:

1. What species and family compositions are characteristic for the spiders living in buildings?
2. How can they be typified as synanthropic species?

3. Where do the species living in the buildings come from?
4. What changes are taking place and at what pace in the urban spider fauna? To what extent has the synanthropic fauna changed over the last 30 years?
5. Is there any health risk associated with the invading new spider species? What to expect?

Materials and methods

This paper is based on publications and on diploma theses of the last 30 years. It summarizes surveys of systematic collections performed in buildings [in more than 50 towns and villages in Hungary, 260 settlements in Slovakia, and one town in Romania (130 residential buildings)]. The collections were done by hand picking the specimens inside the buildings. Due to the fact that the collections were done by many people in different styles and time, these test sites did not allow for any standardization, so the more prominent species are over-represented.

The high number of collectors also increased the diversity of the sampling methods and the possibility of subjective elements. It was assumed that multiple and repeated collections made the monitoring of changes in the fauna of the buildings possible. Those results should be emphasized which was obtained in buildings where the same person was following the fauna for decades. Due to the reasons mentioned above we could not perform the statistical analyses, but the data might be suitable to illustrate trends. From literature data we compiled a list of species detected from buildings in Hungary, Romania and Slovakia. Those species were classified into synanthropy types using an updated categorizing scheme of Sacher (1983) according to Nentwig et al. (2019). For eusynanthropic and hemisynanthropic species, we examined the first recording of their presence in the faunal lists of the three countries.

The synanthropisation types introduced by Valešová (1966) and Sacher (1983) are still applicable today. It is important to state that these concepts should always be specific to the geographical area under consideration. For the eusynanthropic, hemisynanthropic and asynanthropic species, subtypes were constructed as follows:

Eusynanthropic (ES): species living only in synanthropic environment, mainly in buildings

1. ESA: Eusynanthropic aliens (alien/non-native to Europe)
2. ESN: Eusynanthropic native/native mainly Mediterranean, a species native to southern Europe.

Hemisynanthropic (HS): species that typically occur both in synanthropic and in natural environments

1. HS1: Typical Hemisynanthropic
2. HS2: Partial Hemisynanthropic

Asynanthropic (xenanthropic (by Valešová 1966)) (AS): species living only in natural conditions and their occurrence in synanthropic environment is accidental and very rare

1. ASN: Asynanthropic Native/Native (Domestic “vagabonds”)
2. ASA: Asynanthropic Aliens (Alien/Alien Free Riders, From Outside of Europe)
3. ASM: Asynanthropic Mediterranean Guest

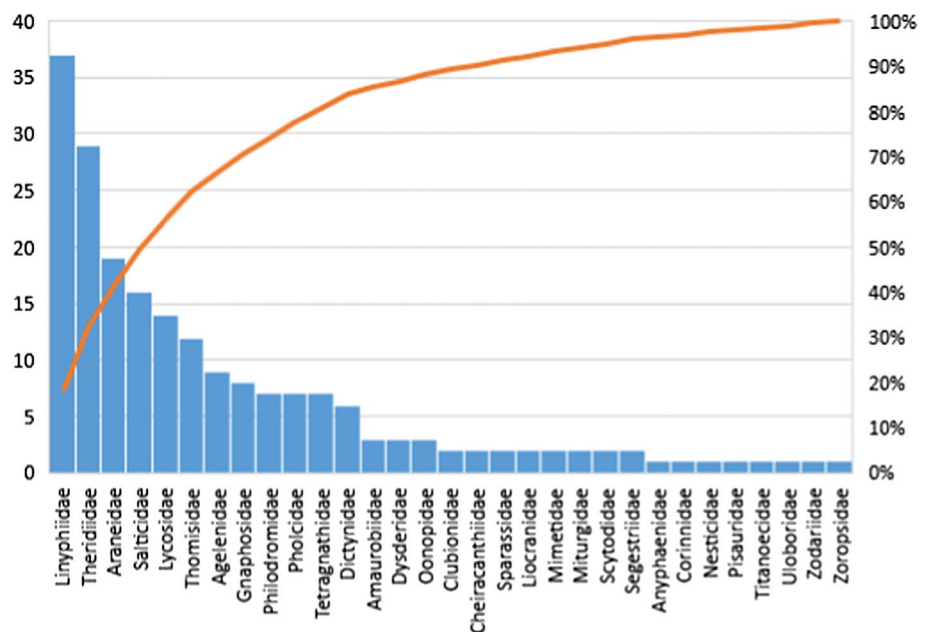
In order to detect any changes over the last three decades, we looked at whether the actual species was included in the faunal list before 1990 or has appeared since.

We also investigated whether there is any difference in the origin of eusynanthropic spiders (native to Europe or native to other continents) known before the 1990s or discovered later.

Results

Based on data from selected publications concerning the study area, we investigated the type of synanthropy for 204 spider species found in buildings. These spiders belong to 31 spider families (Fig. 1). The following 11 families contained the most species: *Linyphiidae*, *Theridiidae*, *Araneidae*, *Salticidae*, *Lycosidae*, *Thomisidae*, *Agelenidae*, *Gnaphosidae*, *Philodromidae*, *Pholcidae*, *Tetragnathidae*.

Fig. 1 Family composition of spider fauna in buildings in the studied region (total number of species: 204, total number of family: 31)



Based on synanthropy types large differences were observed in the composition AS: 165; ES: 23; HS: 16 (Fig. 2).

Out of the 23 eusynanthropic species, 10 have been introduced into the Central European fauna from other continents. If we compare the proportion of European native species with those originated from other continents before and after 1990, the difference is obvious. Among the species present here before 1990 only 22% (2 out of 9) originated from other continents, while for species introduced after 1990 this proportion increased to 57% (8/14).

List of eusynanthropic and hemisynanthropic species, country-by-country presence and appearance (old data

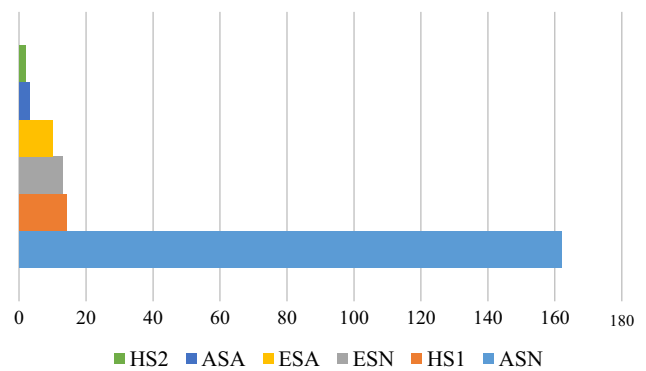


Fig. 2 Distribution of spider species collected in buildings, by type of synanthropy (number of species). *HS2* hemisynanthropic (moderately typical), *ASA* asynanthropic alien, *ESA* eusynanthropic alien, *ESN* eusynanthropic native, *HS1* hemisynanthropic (typical), *ASN* asynanthropic native

before 1990: B, new data after 1990: A) are presented in Table 1.

Individuals of eusynanthropic species can make up to 80% of all collected samples (Szinetár 1992; Párdi and Urák 2009). This proportion varies significantly within a settlement by type of buildings, but also by region of the cities.

Discussion

A sufficiently high sampling effort resulted in a very high number of species detected in any building (Gajdoš et al. in preparation). Spiders enter most buildings easily thus the range of species that are randomly introduced into this

Table 1 Synanthropic spiders in the Carpathian Basin Countries: H: Hungary, RO: Romania, SL: Slovakia; Presence: 1; Absence: 0; Native: N; Aliens (alien/non-native to Europe): A Detected (in buildings) before (B) and after (A) 1990

Species	Family	Country 1/0			Type of S	Origin	In buildings
		SK	RO	H			
Synanthropic spiders in Carpathian Basin							
<i>Tegenaria domestica</i> (Clerck, 1757)	Agelenidae	1	1	1	ES	N	B
<i>Brigittea civica</i> (Lucas, 1850)	Dictynidae	1	1	1	ES	N	B
<i>Oonops domesticus</i> Dalmás, 1916	Oonopidae	1	0	0	ES	N	B
<i>Hoplopholcus forskali</i> (Thorell, 1871)	Pholcidae	1	1	1	ES	N	B
<i>Pholcus phalangioides</i> (Fuesslin, 1775)	Pholcidae	1	1	1	ES	A	B
<i>Scytodes thoracica</i> (Latreille, 1802)	Scytodidae	1	1	1	ES	N	B
<i>Parasteatoda tepidariorum</i> (C. L. Koch, 1841)	Theridiidae	1	1	1	ES	A	B
<i>Steatoda grossa</i> (C. L. Koch, 1838)	Theridiidae	1	1	1	ES	N	B
<i>Steatoda triangulosa</i> (Walckenaer, 1802)	Theridiidae	1	1	1	ES	N	B
<i>Eratigena atrica</i> (C. L. Koch, 1843)	Agelenidae	1	0	1	ES	N	A
<i>Triaeris stenaspis</i> Simon, 1891	Oonopidae	1	0	1	ES	A	A
<i>Holocnemus pluchei</i> (Scopoli, 1763)	Pholcidae	1	0	1	ES	N	A
<i>Pholcus alticeps</i> Spassky, 1932	Pholcidae	1	0	1	ES	N	A
<i>Psilochorus simoni</i> (Berland, 1911)	Pholcidae	0	1	1	ES	A	A
<i>Spermophora senoculata</i> (Dugès, 1836)	Pholcidae	1	1	1	ES	A	A
<i>Hasarius adansoni</i> (Audouin, 1827)	Salticidae	1	0	1	ES	A	A
<i>Pseudeuophrys lanigera</i> (Simon, 1871)	Salticidae	1	1	1	ES	N	A
<i>Scytodes fusca</i> Walckenaer, 1837	Scytodidae	1	0	0	ES	A	A
<i>Coleosoma floridanum</i> Banks, 1900	Theridiidae	1	0	1	ES	A	A
<i>Parasteatoda tabulata</i> (Levi, 1980)	Theridiidae	1	1	0	ES	A	A
<i>Pandava laminata</i> (Thorell, 1878)	Titanoecidae	0	0	1	ES	A	A
<i>Uloborus plumipes</i> Lucas, 1846	Uloboridae	1	0	1	ES	N	A
<i>Zoropsis spinimana</i> (Dufour, 1820)	Zoropsidae	0	0	1	ES	N	A
<i>Tegenaria ferruginea</i> (Panzer, 1804)	Agelenidae	1	1	1	HS1	N	B
<i>Amaurobius ferox</i> (Walckenaer, 1830)	Amaurobiidae	1	1	1	HS1	N	B
<i>Larinioides ixobolus</i> (Thorell, 1873)	Araneidae	1	1	1	HS1	N	B
<i>Larinioides scolopetarius</i> (Clerck, 1757)	Araneidae	1	0	1	HS1	N	B
<i>Leviellus thorelli</i> (Ausserer, 1871)	Araneidae	0	0	1	HS1	N	B
<i>Nuctenea umbratica</i> (Clerck, 1757)	Araneidae	1	1	1	HS1	N	B
<i>Scotophaeus quadripunctatus</i> (Linnaeus, 1758)	Gnaphosidae	1	0	0	HS1	N	B
<i>Scotophaeus scutulatus</i> (L. Koch, 1866)	Gnaphosidae	1	1	1	HS1	N	B
<i>Lepthyphantes leprosus</i> (Ohlert, 1865)	Linyphiidae	1	1	1	HS1	N	B
<i>Liocranum rupicola</i> (Walckenaer, 1830)	Liocranidae	1	0	1	HS1	N	B
<i>Nesticus cellulanus</i> (Clerck, 1757)	Nesticidae	1	1	1	HS1	N	B
<i>Pholcus opilionoides</i> (Schrank, 1781)	Pholcidae	1	1	1	HS1	N	B
<i>Steatoda bipunctata</i> (Linnaeus, 1758)	Theridiidae	1	1	1	HS1	N	B
<i>Steatoda castanea</i> (Clerck, 1757)	Theridiidae	1	1	1	HS1	N	B
<i>Eratigena agrestis</i> (Walckenaer, 1802)	Agelenidae	1	1	1	HS2	N	B
<i>Tegenaria hasperi</i> Chyzer, 1897	Agelenidae	0	0	1	HS2	N	A

environment is constantly expanding. In terms of number of species, asynanthropic species are the most abundant. These are the most frequent in summer and in buildings in close proximity of natural habitats. If we increase the collection effort, the ratio/percentage of asynanthropic elements are increasing, but the abundance of individuals per species remains usually low and considered as rare (Szinetár 1992; Párdi and Urák 2010).

Out of the 204 species included in our study, 165 were asynanthropic. More than 70% of the spider families registered in the region may be represented in the human constructions. Asynanthropic species, wherever they are, avoid man-made, constructed environments. Fortunately, this is also true for the medically important *Latrodectus tredecimguttatus* (Rossi, 1790) which is common in southern Europe, and has very painful, in rare cases fatal bite. A related species living in Australia, the Australian redback spider, *Latrodectus hasselti* (Thorell, 1870) could typically be found close to residences (Vink et al. 2011). This latter species occurs in Europe due to occasional introduction, but has not been able to establish a population here (Nentwig et al. 2019).

Occurrence of asynanthropic species in buildings can be considered as occasional coincidence. Therefore, there is no justification for fear of tropical, medically significant spiders that can only rarely be found in residential areas, even in their original environments. But this does not exclude possible fatal accidents (Bogdán et al. 2005).

Asynanthropic species, especially in the long run, may adapt to some buildings types in which their occurrence may change from occasional to typical. Nevertheless, the abundance of synanthropic species will always prevail (Szinetár 1992; Párdi and Urák 2010). Anthropogenic environments could be appropriate habitats for hemisynanthropic species (HS1, HS2), as well. The key factor of their habitat choice is the similarity to their natural habitat. The most decisive environmental factors are involve habitat structure and humidity. These spiders are long-term co-tenants. We usually found a lot of them in apartments. Their frequency is influenced by the proximity of natural habitats giving similar conditions around the buildings. They are common in rural areas, in villages (e.g. *Tegenaria ferruginea* (Panzer, 1804), *Amaurobius ferox* (Walckenaer, 1830), *Nuctenea umbratica* (Clerck, 1757), *Scotophaeus scutulatus* (L.Koch, 1866), *Steatoda bipunctata* (Linnaeus, 1758)).

Eusynanthropic species tend to inhabit such human settlements/artificial environments as their habitat within their native area, where they are considered hemisynanthropic elements. Therefore, it is important to emphasize the exact geographical location if we want to use the concepts of degrees of synanthropy properly. Eusynanthropes cannot move away from their homes permanently due to climatic reasons, mainly because of the temperature

constrain. Eusynanthropic species of the Carpathian Basin are assumed to be present in buildings due to human introduction. Nentwig (2015) gave a detailed overview of spiders introduced to Europe. His study did not especially target building habitats, but his results may provide a good basis for investigating the origin of the building fauna. According to Nentwig (2015), 165 species of 36 families have been introduced to Europe in the last 200 years, a third of them have become established, primarily, species native to Asia and North America. This finding is well known for eusynanthropic species inhabiting buildings. According to our knowledge, *Pholcus phalangoides* (Fuesslin, 1775) was introduced from Asia. *Spermophora senoculata* (Dugès, 1836) also entered Europe from the Middle East and inhabited the southern and central areas of Europe. It is already present in all the three studied countries of the Carpathian Basin. *Parasteatoda tabulata* (Levi, 1980) and *Pandava laminata* (Thorell, 1878) are also of Asian origin (Nentwig et al. 2019). *Pandava laminata* (Thorell, 1878) is known only from Hungary (Pfliegler et al. 2012), while *Parasteatoda tabulata* (Levi, 1980) is known from Slovakia (Šestáková and Gajdoš 2011) and also from Romania (Párdi and Urák 2010).

Psilochorus simoni (Berland, 1911) was introduced to Europe from North America, and its spreading from the direction of Western Europe could have been observed over the past decades. The species prefers dark cellar spaces, and it is much smaller than, for example, species belonging to genus *Pholcus*, and therefore it is likely to be underrepresented in collections compared to its actual frequency. *Coleosoma floridanum* (Banks, 1900) has an American origin. It was collected by Pfliegler (2014) in the Botanical Garden of the University of Debrecen, and by Šestáková et al. (2013) in the Botanical Garden of the Comenius University. *Parasteatoda tepidariorum* (C. L. Koch, 1841) is a species introduced from South America, whereas *Triaeris stenaspis* (Simon, 1892) originated from Central America. Also, Central and South America is the origin of *Scytodes fusca* (Walckenaer, 1837), which was observed in special greenhouse conditions (botanical garden) in Slovakia (Šestáková et al. 2014). *Hasarius adansoni* (Audouin, 1826) is an introduced species from Africa.

It is worth examining what may have caused the increase in the proportion of detected eusynanthropic species introduced from other continents after 1990. Two explanations seem to be plausible: due to the increased trade and tourism in the past decades, the probability of introduction has become more likely. In addition to this, special attention has been paid to special buildings in which climate is appropriate for these species. These include tropical greenhouses in botanical gardens. It is likely that the distribution of some of these species will continue to be restricted in these specific buildings (e.g. *Coleosoma floridanum* Banks, 1900).

One has to make a distinction between continental native or alien eusynanthropic species. Continental natives are southern European species whose native populations have been well known for a long time. For some of these, the occurrence in Central European buildings is not recent nor surprising. A good example for this is *Brigittea civica* (Lucas, 1850) which is common on the exterior walls of urban structures and can also be found sporadically inside buildings. *Oonops domesticus* (Dalmas, 1916), *Scytodes thoracica* (Latreille, 1802), *Steatoda triangulosa* (Walckenaer, 1802) are also believed to be species with similar characteristics. They are native to Europe, but within the study area they are derived almost exclusively from buildings. This phenomenon, the spreading of southern European species northward in urban environments, was exemplified e.g. by the appearance and spectacular spread of *Zoropsis spinimana* (Dufour, 1820) in Hungary (Szinétár et al. 2014). In Hungary, it could be found only in buildings, but there it has developed stable populations as it was observed in several settlements. A similar pattern can be found for *Holocnemus pluchei* (Scopoli, 1763), which also spreads from southern Europe but still lives in buildings in the Carpathian Basin (Kovács et al. 2006). Gradual house-to-house spreading in small steps, not only from the south but also from the east, is characteristic for some eusynanthropic species. For example, westward spread of *Pholcus alticeps* (Spassky, 1932) was reported from Asia. Similarly, the distribution of *Hoplopholcus forskali* (Thorell, 1871) from the eastern direction seems to have stopped in the Carpathian Basin with West-Hungary being the westernmost area.

A recent example for the spread of a species from the Eastern direction is *Pholcus ponticus* (Thorell, 1875) described in eastern Slovakia in 2019 (Mihoková 2019), known from Ukraine and Romania as a house-dwelling species (Fedoriak and Moscaliuc 2013). Based on several observed specimens, it is assumed that it is already present in several areas of the north-eastern part of the Carpathian Basin and expected to spread further.

In order to demonstrate the changes in the synanthropic fauna of the study areas, we have considered the three decades already mentioned and compared the species characteristic in buildings in the three countries detected before and after 1990. The range of so-called hemisynanthropic species have remained almost unchanged. Native members of our fauna have been given the opportunity to move into buildings for centuries. Among the species spreading between natural habitats from southern Europe to the north are those that appear more frequently in buildings at certain times, but it is not typical for their full life cycle. An example, *Tegegnaria hasperi* (Chyzer, 1897), which was first discovered almost simultaneously from buildings and natural habitats (Szinétár and Vajda 1992).

Nine out of the 23 eusynanthropic species were present in the Carpathian Basin fauna before 1990. A notable result is that 14 species appeared in the Carpathian Basin after 1990 (Table 1).

Conclusion for future biology

What to expect in our buildings—in our built environment?

Based on data from the past decades obtained in the three areas of the Carpathian Basin, as well as on the characteristics of introduction and establishment of spiders over the last 200 years (Nentwig 2015), some preliminary conclusions can be made for the future.

1. The list of spider species inhabiting buildings will probably expand further. If the so far observed tendency remains, we can expect up to one new eusynanthropic species in every 2 years in the Carpathian Basin.
2. Southern European species are expected to appear in urbanized environments, some of which will occasionally be present in buildings. An example for this in recent decades is *Cheiracanthium mildei* (L. Koch, 1864), a spectacularly spreading southern European species. Although most of them live outdoors, they are frequent visitor and overwintering species in homes, even in big cities. It is moderately dangerous, it may also have some hazardous health effects (Szinétár 1992; Kovács and Szinetár 2014).
3. It is expected that an increasing number of eusynanthropic species moves to outer walls or courtyards in the summer (*Pseudeuophrys lanigera* (Simon, 1871) (Szinétár, 2006).
4. New tropical species are expected to arrive through trade or tourism, this is unpredictable, and the actual establishment of the species is also questionable.
5. Heating system modernization of residential buildings or insulation of the basement levels affects the spider species composition of the flats. For example, in the case of the drying out of the rooms, the populations of *Nesticus cellulanus* (Clerck, 1757) are expected to shrink and disappear, whereas those of *Pholcus phalangioides* (Fuesslin, 1775) grow.
6. Changes can be observed even in stable living spaces. The frequency of *Holocnemus pluchei* (Scopoli, 1763) from the *Pholcidae* family increases.
7. Cities are expanding into areas with steppe vegetation (grasslands). Due to this, occasional visitors, including species that are not typically found in homes such as *Geolycosa vultuosa* (C. L. Koch, 1838) and mainly *Lycosa singoriensis* (Laxmann, 1770), appear in buildings, especially in certain periods (e.g. in the mating

season). In Hungary and southern Slovakia, this has attracted public attention in the last few years.

8. Migration of some cave-dwelling (troglophile) species into buildings might be accelerated. Brandmayr and Pizzolotto (2016) associated the increasing number of cave-dwelling Carabid beetle species with warming. If the hypothesis is true, we expect an increase in the appearance of cave-dwelling species—primarily from southern Europe or Asia Minor—in special built environments—sewer systems, tunnels (not necessarily homes). Presumably, this may also have played a role in the northward spread of the *Kryptonesticus eremita* (Simon, 1880) (Szabó and Szinetár 2018). The syn-tropic environment does not provide an alternative to the true cave spider species (trogloniont) (Mammola et al. 2018).
9. It is unlikely that a permanent population of a house-dwelling species that present a significant danger to human health would appear. Therefore, such fear of spiders in the Carpathian Basin is unjustified. The importance of spiders, spontaneously inhabiting our dwellings and our surroundings expected to increase as biological insect control agents, because the non-biological forms of chemical mosquito control will be restricted in the near future. In Hungary, aerial spraying with non-selective poisons will be banned in 2020.
10. To keep up to date with the above changes, it is still necessary to study the spider fauna of the built environment.

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