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Spider (Arachnida: Araneae) communities on reinforced terraces of the Neris River in Vilnius

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Abstract
Epigeic spider communities were studied on the terraces of the Neris River reinforced with perforated concrete slabs. The research was carried out in the central part of Vilnius, Lithuania. Pitfall traps were used for collecting the material at seven sites. Communities formed in urban ecosystems have been studied for the first time in Lithuania. A total of 2461 adult specimens belonging to 50 species and 15 families were registered. *Xerolycosa miniata* was the most numerous species as well as the dominant species at all sites investigated. The number of species and the diversity index of most urban communities were approximately two times lower in comparison to the communities outside the city. The composition of species found in these habitats was unique and differed from communities observed in other open habitats in Lithuania, as well as from other urban habitats investigated in European cities. Terraces were inhabited by some rarely found species (*Zelotes aeneus*, *Thanatus arenarius*, and *Meioneta fuscipalpa*) which appear to have established permanent populations. The formation of typical communities on the newly created terrace habitats begins in the first years after the creation of the habitat. The communities at the age of 18 – 24 years are quite similar to each other, with no significant differences between them. The management of terraces by means of haymaking and bush cutting could be regarded as useful for keeping the conditions required by some rare xerophilic spider species.

Key words: Araneae, urban ecosystems, artificial habitats, Lithuania.

INTRODUCTION

Many urban habitats are highly influenced and constantly being created by man. Cities and industrial areas are places where many new habitats are continuously created. Most of them are artificial habitats that do not exist in nature. Spiders are among the first invertebrate dwellers colonizing these newly created habitats. The spider fauna of urban areas and recultivated habitats has received considerable attention from scientists. It has been investigated in Berlin, Warsaw, and Cologne (Broen 1977; Krzyzanowska 1981; Salz 1992). Many practical and theoretical questions have been discussed based on these investigations (Schaefer 1973; Schaefer & Kock 1979; Wipking 1992). Despite these studies, there is still not sufficient information on spider communities in the artificial urban habitats. Also very little information is known about the first stages of succession of spider communities in artificial habitats. Meijer (1973), Mader (1985) and Snazell & Clarke (2000) studied the initial stages of colonization and formation of communities on newly created habitats, but no one has studied these processes in city areas. The aim of our study was to investigate spider communities on the Neris River reinforced terraces.

INVESTIGATION AREA

Reinforcement of the Neris River terraces in the central part of Vilnius with perforated concrete slabs started in 1976. The last reinforcement around a newly built bridge was completed in 1999 (one year before the present investigation was carried out). The descending slopes of the river terraces were covered with gravel and perforated concrete slabs (2.06x1.07 m in size). Each slab has eight holes of 0.35x0.35 m in size. There are about 5 km of such reinforced terraces in the central part of the city (Fig. 1). The slope of the studied terraces is 25-30 degrees facing south or southwest. Such orientation and the absence of gross herbaceous vegetation form open and sun exposed surfaces. Excurrent groundwater in connection with high air temperature creates " moist-hot" or muggy conditions on the epigeic layer of the habitat at some sites. Vilnius (ca. 630.000 inhabitants) can be considered as a " green" city. Large park areas and large fragments of semi-natural forests or open areas stretch deeply into the central part of the city. There are few areas well isolated from semi-natural habitats.

Seven sites were selected along the reinforced terraces. Six of them were 24-18 years old and had undergone some renaturalization processes. The seventh site was newly created in 1999. The site OLD 3 is the part of the terrace created at the same time as OLD 4, but it is not covered with concrete slabs.

OLD 1: 18 years old. Height of vegetation is up to 30 cm in spring and early summer. The coverage of vegetation is 62%. The concrete slabs are covered with a thin layer of mosses and lichens.

OLD 2: 23 years old. Vegetation is sparse and up to 25 cm high. Coverage is 40%. Some areas of bare concrete still remain.

OLD 3: 24 years old. The terrace is not reinforced with slabs. Dense and homogenous vegetation together with a layer of humus and necromass build a dense greensward. Coverage is 76%.

OLD 4: 24 years old. It is an area below OLD 3. Vegetation is scanty and dies off during summer. Coverage is 30%. The open ground is built up from small stones and coarse gravel.

OLD 5: 22 years old. Vegetation is low and dense. Almost all of the surface of the concrete slabs is covered with thin layer of mosses and lichens. A well-developed layer of green mosses fills up the places among concrete slabs. Coverage of vegetation is 57%.

OLD 6: 20 years old. This area has the most expressed vegetation in comparison to other studied sites. The height of the vegetation is up to 40 cm in early summer. Coverage is 87%. The ground is completely covered with necromass and humus. Only small patches of concrete slabs are visible. Environmental conditions undergo substantial changes after haymaking in early and late summer.

NEW 1: Fig 2. One year old. This is a newly reinforced terrace by a new bridge. Vegetation coverage is 7%. There are no mosses, lichens, necromass or humus on the ground. The holes among concrete slabs are filled with clayed gravel.

MATERIAL AND METHODS

Spiders were collected by means of pitfall traps. Five pitfall traps (plastic jars, volume 250 ml, depth 10 cm, diameter 7 cm) filled with 100-150 ml of 4% formaldehyde solution mixed with some detergent were used at each site. Traps were placed randomly at 4-5 m distance from each other. They were operated from 7 April 2000 to 17 October 2000 and emptied every three weeks. Altogether nine samples were taken.

The environmental conditions were assessed using indicator values of vegetation (Ellenberg 1991). The cover of vegetation, which is the percentage of all vegetation covering the ground surface of the investigated site, was estimated using quadrat method. The estimations of the ground cover were performed twice. Each time, the quadrat frame (0.5x0.5m) gridded in 25 sub-squares

(0.1x0.1m) was randomly deployed eight times at each investigated site. The ground cover in percent was estimated within each sub-square and the overall cover was calculated as an average of cover in all sub-squares.

The similarities of dominance levels of spider species at the different sites were counted using percentage similarity index. The Sørensen coefficient of species similarity was calculated for the whole set of species, and for the sets of species represented by four or more specimens in the community. The diversity index of Shannon-Wiener (log base 2) was used to compare internal complexity of community structure. More details and the formulas for calculating the aforementioned indices of similarity and diversity can be obtained from Krebs (1989). The nomenclature of spiders follows Platnick (2002).

RESULTS

Community structure

A total of 2461 adult specimens belonging to 50 species and 15 families were collected during the study. The material collected at different sites did not show large differences in the number of collected species. The number of species ranged from 16 in OLD 2 to 24 in OLD 6 (Table 1). The highest number of species (24) was found on the site with the most complex and best-developed vegetation cover (OLD 6). The total numbers of species registered at different sites were considerably lower (average 20 species) than those found in ruderal suburban habitats located about 10 km from the area of studies (average 56 species) (D. Mikelaitis unpublished data). The number of specimens varied greatly and showed a significant positive correlation with the vegetation coverage (Fig. 3). The total numbers of specimens collected were mainly affected by the variable abundance of *Xerolycosa miniata* (C.L. Koch, 1834) that highly dominated all old sites (Table 2). The difference in the cumulative number of specimens (73-135 specimens) belonging to the rest of species was less expressed. The high abundance of *Xerolycosa* *miniata* influenced most of the quantitative comparisons as well as comparisons between community parameters and environmental factors. The large number of *X. miniata* caused low values of diversity indices, which were low at places with sparse vegetation or high humidity (Table 2).

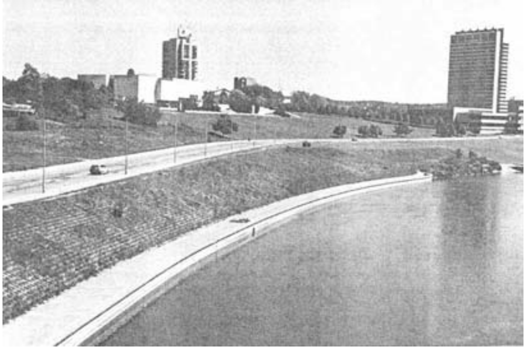

Fig. 1. Reinforced terraces of the Neris River in Vilnius with site OLD 5.

Fig. 2. The youngest reinforced site NEW 1 (one year old).

Table 1. The number of species and specimens found in the communities studied in Vilnius.
S: number of species. N: number of specimens. S (N>3): number of species represented by four or more specimens particular site.

Site	S	N	S (N>3)
OLD 1	22	346	8
OLD 2	16	210	7
OLD 3	19	525	12
OLD 4	17	336	7
OLD 5	21	336	10
OLD 6	24	574	12
NEW 1	19	134	10

Table 2. The dominance of *X. miniata* and the index of diversity Hs (log base 2) of spider communities studied in Vilnius in 2000. The highest and lowest values are in bold.

Site	Hs	*X. miniata* (%)
all species		
OLD 1	1.966	68.8%
OLD 2	2.207	60.5%
OLD 3	1.420	**80.9%**
OLD 4	1.464	78.3%
OLD 5	1.828	71.1%
OLD 6	1.645	76.5%
NEW 1	3.501	**17.9%**
species N>3		
OLD 1	1.409	74.4%
OLD 2	1.745	65.1%
OLD 3	1.231	**82.8%**
OLD 4	1.047	82.7%
OLD 5	1.465	74.7%
OLD 6	1.392	78.8%
NEW 1	2.971	**27.9%**

Only a small number (7-12) of species represented by four or more specimens was found. The highest number (12) of abundant species (N>3) was found at sites with continuous vegetation cover (OLD 3 and OLD 6). Most of the abundant species (63.1%) were found on the most natural and not reinforced site (OLD 3) followed by OLD 6, where 50% of all species belonged to the "abundant" group).

Only four species (*Pardosa palustris* (Linnaeus, 1758), *Phrurolithus festivus* (C.L. Koch, 1835), *Thanatus arenarius* (L. Koch, 1872), and *Xysticus kochi* Thorell, 1872) were found at all sites. Two species (*Meioneta fuscipalpa* (C.L. Koch, 1836) and *Phlegra fasciata* (Hahn, 1826)) were found at all the old sites, but not at the new.

A few species were more abundant or were found only at sites with well developed plant cover: *Pelecopsis parallela* (Wider, 1834) (11), *Zelotes clivicola* (L. Koch 1870) (9), *Xysticus cristatus* (Clerck, 1757) (16) at OLD 3 and *Diplocephalus connatus* Bertkau, 1889 (12) at OLD 6.

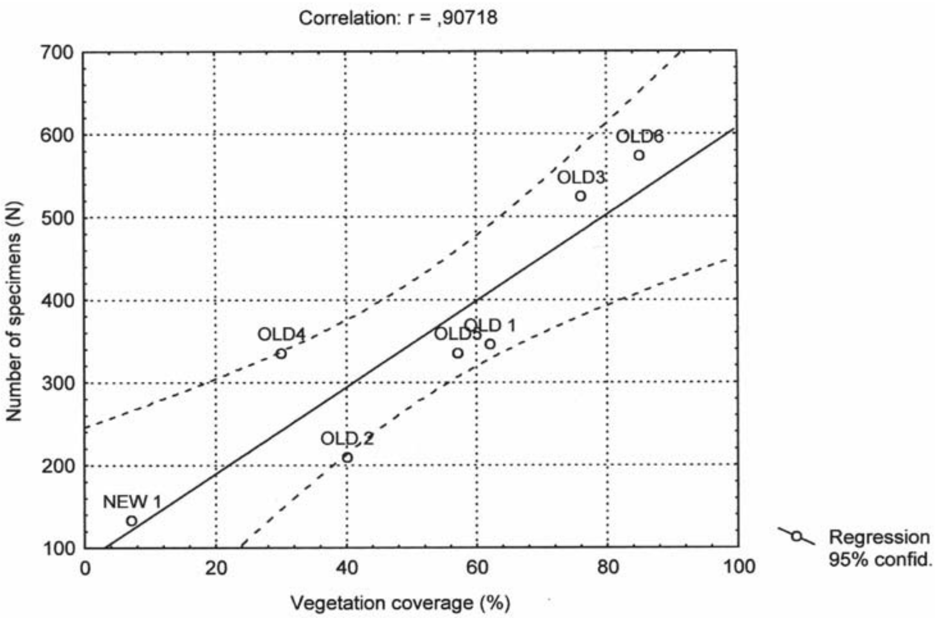

Fig. 3. Relationship between the coverage of vegetation and the number of specimens in the spider communities studied.

Despite supposedly appropriate habitat structure (retreats and vegetation structure), only few species of Gnaphosidae were found at all studied sites. The number of Linyphiidae was also low. *Tegenaria atrica* (C.L. Koch, 1843) was recorded for the first time in an outdoor habitat in Lithuania (site OLD 2).

Similarity

The spider fauna found in the communities at old sites were quite similar to each other, especially in the case of abundant species (Appendix). Despite variable conditions, the faunas overlapped highly at the different sites. The greatest difference in species similarity and community structure was revealed between old and new habitats. The set of all, as well as that of abundant species (N>3), was more similar between closely located new and old habitats (NEW 1 and OLD 6) than between old (OLD 6) and other more distant old sites (Fig. 4B,C).

The highest similarity of the community structure (percentage similarity) was revealed between closely located communities (OLD 4 and OLD 5). Despite a large distance, the community structure was also very similar at sites (OLD 3 and OLD 6) (Fig. 4A). Thus, the similarity can be probably affected by distance between sites, as well as by environmental factors.

We found only minor differences comparing spider faunas between neighbouring (distance about 20 m) sites with (OLD 4) and without (OLD 3) concrete slabs.

In a meadow (OLD 3) only three new species (*Mecynargus foveatus* (Dahl, 1912) , *P. parallela*, and *Zelotes electus* (C.L. Koch, 1839)) were found in comparison to all reinforced habitats. Unlike reinforced habitats, the meadow had more abundant (N>3) species.

Initial stages of succession

The number of specimens in the new habitat was considerably lower than at older sites, but the number of species was very similar. Fifteen out of 19 species (78.9 %) of the species found in the new habitat were also common in old habitats. Despite great differences in habitat structure, *Oedothorax apicatus* (Blackwall, 1850) was found in both NEW 1 and the closely located site OLD 6. This species was not collected in any of the other old localities. Comparison with old sites shows that most of the colonizing species probably arrive at the new habitat on the ground or by air from adjacent habitats. The impact of species immigrating from distant open habitats can be regarded as minimal, or to be at the same level as in old habitats. *X. miniata* was already dominant species in the new habitat, but its dominance was not as big as in old areas. This site was the only locality where *M. fuscipalpa* was absent, while *M. rurestris* reached its highest abundance here in comparison to other habitats. Two other opportunistic species (*Diplostyla concolor* (Wider, 1834) and *Pachygnatha clercki* Sundevall, 1823) were more abundant in this new habitat than in old ones, but the low abundance of these species does not allow these differences to be considered significant (Appendix). A few rare or new for Lithuania spider species were found in this new habitat: (*Zelotes aeneus* (Simon, 1878), *Tegenaria agrestis* (Walckenaer, 1802), and *Thanatus arenarius*).

New species for Lithuania

Four species found during the studies were new to the Lithuanian fauna. These are *Mecynargus foveatus* (Dahl, 1912), *Meioneta fuscipalpa* (C.L. Koch, 1836), *Tegenaria agrestis* (Walckenaer, 1802) and *Thanatus arenarius* (L. Koch, 1872) (Appendix). The high abundance of *Th. arenarius* and *M. fuscipalpa* at some sites shows that they have established permanent populations in the whole investigated area. *M. fuscipalpa* is probably more common in urban habitats than in other ones. In 2001 *Th. arenarius* was found to be abundant in the dry suburban habitats surrounding Vilnius (D. Mikelaitis unpublished data).

DISCUSSION AND CONCLUSIONS

Despite variable conditions, the spider fauna at different sites highly overlaped. Low abundance in the majority of the recorded species does not allow us to state that they would be permanent inhabitants of the studied sites. We cannot exclude that these artificial habitats are permanently invaded by species living elsewhere, while only a small number of species are permanent residents. Most differences were caused by the occurrence of not abundant species.

Species richness and the values of the diversity indices at the investigated artificial urban habitats were approximately twice lower than in natural or semi-natural open areas. The low number of species points out that possibly only a limited number of species lives in the surrounding areas that are able to colonize these new habitats. On the other hand, some of the arriving spiders could be outcompeted by the highly dominating *Xerolycosa miniata*. Bishop & Riechert (1990) noticed that competition has favoured the cursorial spiders (in our case probably *X. miniata*) over the balllooners. This can also be true in the case of other less abundant cursorial invaders. Bishop & Riechert (1990) pointed out that aerial dispersal of spiders is the major mode of arrival in agricultural ecosystems. The data from the young habitat support the assumption that ballooning as well as migration by ground (cursorial) from adjacent habitats are the major modes of arrival in our case, because most of the species colonizing this new habitat were known in the older habitats. The effect of the ballooning from distant habitats in urban environment is more questionable, and it is probably more likely in not abundant, transient species.

The extreme dominance of *X. miniata* and high diversity of locally occurring, not abundant species show that communities built up on terraces reinforced with perforated slabs were unique and not similar to spider communities found in other open urban and suburban habitats.

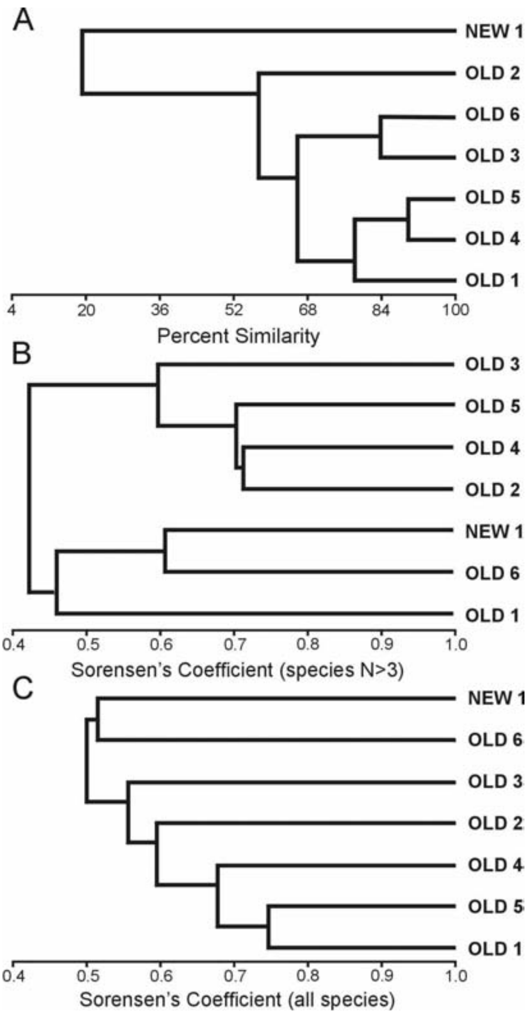

Fig. 4. Similarity of the spider communities on the reinforced terraces of the Neris River in Vilnius. (**A**)–percentage similarity; (**B**)–Sørensen's coefficient (species N>3); (**C**)–Sørensen's coefficient (all species).

No essential differences in the abundance of "pioneer" species were found in the young habitat in comparison to the old ones. Only the higher abundance of *Meioneta rurestris* (C. L. Koch, 1836) was recorded in the young habitat compared to the old habitats.

The case of the young habitat shows that a typical community found at old sites starts to form during these initial years, but only a few species can be supposed to have established a permanent population. High species similarity between young and nearby old habitats probably supports the great importance of neighbouring habitats for colonizing new ones in the case of open habitats despite the apparent differences in environmental conditions.

Few species were more abundant or occurred only in a young habitat. The first stages of colonization are characterized by a high number of the " pioneer" species *M. rurestris*, which was less abundant in older habitats. It is probably replaced during the succession by *M. fuscipala*, which was found abundantly in five of the old sites. *T. agrestis* and *Z. aeneus* were found abundantly in the young habitat too. These are southern species preferring warm, sun-exposed habitats. It is difficult to state whether the increasing pressure of *X. miniata*, or the overgrowth of vegetation are limiting factors for these species, as *Z. aeneus* does not occur in older habitats and only three specimens of *T. agrestis* were found in one old site (OLD 4). The occurrence of juvenile and subadult specimens of the above mentioned species in young habitats reflect their great ability to conquer new sites.

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Appendix. Species and the number of specimens of spiders at sites of reinforced Neris River terrace in Vilnius (Lithuania) studied in 2000.

Species / Sites	OLD 1	OLD 2	OLD 3	OLD 4	OLD 5	OLD 6	NEW 1	TOTAL
Robertus lividus (Blackwall)				1		1		2
Centromerita bicolor (Blackwall)						1		1
Centromerus sylvaticus (Blackwall)						1		1
Dicymbium nigrum (Blackwall)						1		1
Diplocephalus connatus Bertkau						12		12
Diplostyla concolor (Wider)	2				4	4	6	16
Erigone atra Blackwall		1	1					2
Erigone dentipalpis (Wider)			1				1	2
Mecynargus foveatus (Dahl)			4					4
Meioneta fuscipalpa (C.L. Koch)	1	28	8	25	38	37		137
Meioneta rurestris (C.L. Koch)	15		1	2	1	16	33	68
Micrargus subaequalis (Westring)						1	1	2
Microlinyphia pusilla (Sundevall)		1						1
Oedothorax apicatus (Blackwall)						5	4	9
Palliduphantes pallidus (O.P.-Cambr.)					1			1
Pelecopsis parallela (Wider)			11					11
Stemonyphantes lineatus (Linnaeus)	2	1		5		8		16
Walckenaeria capito (Westring)							1	1
Pachygnatha clercki Sundevall	2			1	1		4	8
Pachygnatha degeeri Sundevall			3			2		5
Larinioides sclopetarius (Clerck)	1				1			2
Alopecosa cuneata (Clerck)	3		9		5			17
Pardosa agrestis (Westring)				1	4	5	13	23
Pardosa palustris (Linnaeus)	3	2	4	8	8	2	3	30
Pardosa prativaga (L. Koch)	3	2		2	1		2	10
Pardosa pullata (Clerck)	2						1	3
Pirata hygrophilus Thorell							1	1
Pirata piraticus (Clerck)			1		1			2
Trochosa ruricola (De Geer)	1	3			3	2	3	12
Xerolycosa miniata (C. L. Koch)	238	127	425	263	239	439	24	1755
Dolomedes fimbriatus (Clerck)		1						1
Tegenaria agrestis (Walckenaer)				3			7	10
Tegenaria atrica C. L. Koch		1						1
Hahnia nava (Blackwall)						1		1
Cicurina cicur (Fabricius)	2	9	11	9	6			37
Phrurolithus festivus (C. L. Koch)	34	10	2	4	7	14	9	80
Cheiracanthium virescens (Sundevall)			3	2				5
Clubiona neglecta O.P.-Cambr.					1	1		2
Clubiona similis L. Koch						1		1
Micaria pulicaria (Sundevall)	1							1
Zelotes aeneus (Simon)							10	10
Zelotes electus (C. L. Koch)			9					9
Thanatus arenarius Thorell	17	7	4	3	5	5	8	49
Xysticus cristatus (Clerck)	1	3	16			3		23
Xysticus kochi Thorell	2	8	6	1	3	4	3	27
Euophrys frontalis (Walckenaer)	4							4
Heliophanus flavipes Hahn					2			2
Phlegra fasciata Hahn	4	6	6	4	4	8		32
Talavera aequipes (O.P.-Cambr.)	4			2	1			7
Talavera petrensis C. L. Koch	4							4
Number of specimens	**346**	**210**	**525**	**336**	**336**	**574**	**134**	**2461**
Number of species	**22**	**16**	**19**	**17**	**21**	**24**	**19**	**50**