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Abstract

We studied ground-dwelling spiders along a rural–suburban–urban forest gradient representing increasing human disturbance using pitfall traps. We tested four known and two novel hypotheses: (1) increasing disturbance hypothesis (species richness is decreasing by disturbance); (2) matrix species hypothesis (the richness of open-habitat species is increasing by disturbance); (3) opportunistic species hypothesis (the richness of generalist species is increasing by disturbance); and (4) habitat specialist hypothesis (the number of the forest specialist species is decreasing by disturbance). As a consequence of urbanization, urban forests become drier and more open; thus, according to the new hypotheses, the number of (5) xerophilous species and (6) light-preferring species are increasing in the urban area. Our result did not support the increasing disturbance hypothesis, as the overall species richness increased from the rural sites to the urban ones. As predicted, the number of both the open-habitat and the generalist species increased towards the urban sites. The number of forest specialist species was higher in the suburban area than in the rural and urban area. Both

	xerophilous and light-preferring species were the most numerous in the urban area, supporting the xerophilous species and the light-preferring species hypotheses. Canonical correspondence analysis showed that the forest specialist species associated with the rural sites with higher amounts of decaying woods and more herbs or with the suburban sites with higher cover of leaf litter and higher relative humidity. Two generalist species and one open habitat species were characteristic of urban sites with higher ground surface and air temperature.
Keywords (separated by '-')	Globenet - Disturbance - Xerophilous species - Light-preferring species - Environmental factors
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ORIGINAL ARTICLE

Roland Horváth · Tibor Magura · Béla Tóthmérész

Ignoring ecological demands masks the real effect of urbanization: a case study of ground-dwelling spiders along a rural–urban gradient in a lowland forest in Hungary

Received: 8 May 2012 / Accepted: 30 August 2012

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Keywords Globenet · Disturbance · Xerophilous species · Light-preferring species · Environmental factors

Introduction

The human population is rising exponentially and currently more than 7 billion people live in the world. More than 50 % of humanity lives in and around cities (UNPD 2005). The prediction shows that this proportion will be more than 60 % by 2025 (Antrop 2000). Increased human activities affect almost all species live on Earth. These are resulting in a vast amount of biodiversity loss, modifications, and alteration of natural habitats. The most intensively managed, modified, and fragmented areas by humans are the urbanized habitats primarily in the bigger cities (Gibb and Hochuli 2002; Miyashita et al. 1998; Shochat et al. 2004). Urbanization processes are similar all around the world and these effects are major in the city centers than in the rural parts of cities (Magura et al. 2010a). The urban forests are usually more fragmented, more polluted, warmer, more open, and drier than the natural ones (Marshall and Shortle 2005; Venn et al. 2003). Therefore, the urbanized habitat patches are considerably different from the rural habitats. From the surrounding habitats more non-native and invasive species can penetrate in urban forest fragments (McIntyre 2000; Tóthmérész et al. 2011). Besides, more exotic plant and animal species may appear in the fragmented urban patches. In contrast, lots of original plant and animal species disappear from these habitats or decrease their number

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(Marzluff et al. 2001). Therefore, the negative environmental effects should be minimized.

The aim of an international research framework, called Globenet, was to assess and compare the influence of urbanization on arthropods biodiversity in different countries worldwide (Niemelä et al. 2000). The Globenet program regards a rural–suburban–urban forested gradient, representing different levels of human disturbance (Pickett et al. 2001), using a common sampling methodology (pitfall trap) and some target of ground-dwelling invertebrates (ground beetles, isopods, and spiders) across different parts of the world. Most of the published articles within this framework focus on ground beetles (Elek and Lövei 2007; Gaublomme et al. 2008; Ishitani et al. 2003; Magura et al. 2004, 2008b, c, d, 2010a; Niemelä et al. 2002; Sadler et al. 2006; Tóthmérész et al. 2011), while the study of other arthropod taxa are limited (for spiders: Alaruikka et al. 2002; Magura et al. 2008d, 2010b; for isopods: Hornung et al. 2007; Magura et al. 2008a, d; Vilisics et al. 2007). To assess whether there are general trends of urbanization on arthropods, therefore other indicator taxa (like spider; e.g., Horváth et al. 2001, 2009; Lawes et al. 2005; Willett 2001) should also be investigated along rural–urban gradients.

Species with different ecological demands respond variously to the natural and anthropogenic disturbances (Langor and Spence 2006; Lövei et al. 2006; Magura et al. 2010a). Therefore, it is important to investigate the groups of species with different ecological demands separately. These studies can provide help for experts before planning different managements. We selected spiders (Araneae) for this study because they are fairly easy to collect and preserve, diverse and abundant, taxonomically and ecologically well known, include sensitive specialist and less sensitive generalist species. Moreover, spiders can be found nearly everywhere, and being mobile and relatively short-lived; they may adjust rapidly to changes in abiotic and biotic environmental variables and human disturbances (Foelix 2011; Wise 1993).

There are several hypotheses to explain the effects of human disturbances on biotas (Niemelä et al. 2000; Rebele 1994). We tested four classical and two novel hypotheses regarding the response of species to urbanization. (1) The *increasing disturbance hypothesis* claims that species richness monotonously decreases with the increasing levels of disturbance (Gray 1989). Species with different ecological demands show specific reactions to disturbance. (2) The *matrix species hypothesis* suggests that the matrix (open habitat) species penetrating from the surrounding open habitat; therefore, the dominance of these species increase from the rural sites to the urban ones (Tóthmérész et al. 2011). (3) Opportunistic species are able to benefit from the high level of disturbance, and their dominance should be the highest in the heavily disturbed urban sites (*opportunistic species hypothesis*) (Gray 1989). (4) The *habitat specialist hypothesis* predicts that the abundance and species richness of forest specialist species decreases with the increasing disturbance from the rural area to the urban one (Magura et al. 2004).

In the habitat choice of spiders, the light and humidity conditions of the environment play vital role. Buchar and Ruzicka (2002) pointed out that the light and humidity demands of a species may differ. For example, a light-preferring species may also be humidity-preferring; therefore, we also tested two novel hypotheses: (5) urbanization decreases the humidity of forest; thus, the abundance of xerophilous species should increase from the rural habitat to the urban one (*xerophilous species hypothesis*). (6) As a result of urbanization, the urban forest become more open and lighter; therefore the diversity of light-preferring species increase along the gradient from the rural area towards the urban one (*light-preferring species hypothesis*). We also tested the effects of urbanization on the occurrence of the most frequent spider species along a rural–suburban–urban gradient. The abundance of the most frequent spider species, which the number of individuals made up at least 5 % of the total catch, was also studied along the rural–urban gradient. We also investigated the relationships between the abundance of the most frequent spider species and several environmental variables along the gradient.

Methods

Study area

The study areas were along a rural–urban gradient in and around Debrecen city (eastern Hungary, 47°32′N; 21°38′E), the second largest city of Hungary near the eastern border of Hungary (Magura et al. 2004). We selected three sampling areas (rural, suburban, and urban forests) along an urbanization gradient in the city and in the adjacent forest (Nagyerdő Forest Reserve). All selected areas were in a once-continuous old (older than 100 years) native *Convallario-Quercetum* forest association. All sampling areas were larger than 6 ha. We characterized the level of urbanization by the ratio of the built-up area (buildings, roads, and asphalt-covered paths) to the natural habitats measured by the ArcGIS program (ESRI Software 2004) using an aerial photograph. In the rural area, the built-up area was 0 % (there were no buildings). Therefore, the forest was continuous. In the suburban area, about 30 % of the surface was built-up or tiled; while in the urban area the built-up area exceeded 60 % (this area was very built-up and drastically different from the original forest habitat). The distance between the forested areas (rural, suburban, and urban) was 1–3 km. Further disturbance types were the presence of people and the intensity of forestry/habitat maintenance operations among the areas. In the rural forest area, there were occasional low-intensity forestry management operations. Only a small portion of the paths was asphalt-covered. In the suburban sites, while the understory was not thinned, the fallen trees and branches were also regularly removed. In this area, most paths were not asphalt-covered. In the urban forested area the fallen trees and branches were frequently removed, besides in this area there were several asphalt-covered paths, increasing the isolation between the forested patches and the shrub layer was strongly thinned, resulting in a park character. Grass between the urban patches was frequently mown, and the mowed grass was removed.

Sampling design

We selected two sites per urbanization stage, at least 100 m apart, within each sampling area (rural, suburban, and urban). We collected spiders using pitfall traps from three sampling areas of two sites. We placed ten traps randomly at least 10 m apart from each other at each site. The result was a total of 60 traps scattered along the rural–urban gradient (3 areas × 2 sites × 10 traps). In order to avoid edge effects, each pitfall trap was at least 50 m from the nearest forest edge (Horváth et al. 2002). The pitfall traps were unbaited, and made of plastic cups (65 mm in diameter) filled with approximately 100 ml of 4 % formaldehyde as a killing-preserving liquid. We covered the traps with fiberboard to protect them from litter and rain. We collected spider species fortnightly from the end of April to the end of October 2009. For the statistical analyses, we pooled pitfall samples for the whole year.

Data analyses

We grouped the ecological demands (forest, generalist, and open-habitat species, as well as xerophilous and light-preferring species) of the collected species from the literature (Alaruikka et al. 2002; Buchar and Ruzicka 2002; Electronic Supplementary Material (ESM) Table 1).

GLMs based on Poisson distribution were used to test differences in the overall spider species richness and the species richness of the spiders with different ecological demands among the three sampling areas (rural, suburban, urban), among the six sites. We used data from the individual traps. Sites were nested within the sampling areas; therefore, we used nested design. The response variable (species richness or abundance) was defined as following a Poisson distribution (with log link function). The Poisson distribution assumes that the mean and variance are equal. Real data do not follow this, and the variance is often much larger than the mean (O'Hara and Kotze 2010). This biological reality (overdispersion) was also incorporated into the model using the Pearson Chi-square (quasi-Poisson distribution). That is, GLMs based on quasi-Poisson distribution were used. For multiple comparisons among means, a Tukey test was performed, when GLM showed a significant difference between the means (StatSoft Inc. 2010).

We measured eight environmental variables that were assumed to affect the distribution of spiders (Oxbrough et al. 2005; Pearce et al. 2004). We measured ground temperature at 2 cm depth, air temperature, and relative humidity on the soil surface at each trap monthly on the morning of a typical sunny day. The statistical analyses were based on the averages of the monthly measures. We also estimated the percentage cover of leaf litter, decaying wood material, herbs, shrubs, and canopy cover around each trap within a 2 × 2 m quadrat (Table 1).

We examined the relationships between the environmental measurements and the abundance of the most frequent species using the detrended canonical correspondence analysis by second-order polynomials (DCCA) calculated by the CANOCO package (ter Braak and Šmilauer 2002). Biplot scaling in the ordination was symmetric (focusing on both the inter-species and inter-samples distances). We analyzed the most frequent five species because the abundance of the other species was low.

Results

During the study, we trapped altogether 4,959 individuals belonging to 69 species (Table 1 in ESM). In the rural area, we collected 1,521 individuals belonging to 40 species, 46 species and 1,636 individuals in the suburban area, and in the urban area 1,802 individuals representing 46 species. The dominant species was *Pardosa alacris*, which made up 32 % of the total catch. This

Table 1 Average values (±SE) of the environmental variables in three study areas

Environmental variables	Rural	Suburban	Urban
Ground temperature (°C)	21.1 ± 0.266	22.1 ± 0.109	25.9 ± 0.361
Air temperature (°C)	27.3 ± 0.257	27.3 ± 0.075	31.4 ± 0.206
Relative humidity (%)	59.6 ± 0.682	77.4 ± 0.625	60.1 ± 0.743
Cover of leaf litter (%)	21.1 ± 3.480	69.9 ± 2.045	11.8 ± 2.756
Cover of decaying wood material (%)	10.4 ± 2.110	4.4 ± 0.765	4.1 ± 0.688
Cover of herbs (%)	70.8 ± 3.282	20.5 ± 2.693	48.4 ± 7.251
Cover of shrubs (%)	12.3 ± 3.541	55.4 ± 4.165	28.7 ± 5.508
Canopy cover (%)	56.7 ± 2.741	55.0 ± 3.639	42.3 ± 3.920

species was the most numerous in the suburban and urban habitats, while in the rural habitat *Diplostyla concolor* was the most numerous (here *Pardosa alacris* was the second numerous species). In all habitats, *Ozyptila praticola* and *Trochosa terricola* were also numerous. In the rural forest, *Liocranoeca striata* was numerous. In the suburban area, *Diplostyla concolor* and *Cozyptila blackwalli*; and in the urban habitat, *Trachyzelotes pedestris*, *Liocranoeca striata and Cozyptila blackwalli* were also numerous (Table 1 in ESM). Regarding the ecological demands of the spider species, there were 3,141 individuals of 29 forest species, whereas 1,467 individuals belonged to 29 generalist species, 340 individuals represented ten open-habitat species, 1,689 individuals belonged to six xerophilous species, 330 individuals represented ten light-preferring species, and 11 individuals of one species, which could be determined only at genus level (Table 1 in ESM).

The total species number increased significantly from the rural sites to the urban ones ($\chi^2 = 32.0581$; $df = 2{,}3$; $p < 0.001$, Fig. 1a). There was a similar tendency in the case of open-habitat and generalist spiders, whose species number were significantly lower in the rural and suburban habitats than in the urban sites (species number of open-habitat species: $\chi^2 = 19.0246$; $df = 2{,}3$; $p < 0.001$, Fig. 1b; species number of generalist species: $\chi^2 = 65.7374$; $df = 2{,}3$; $p < 0.001$, Fig. 1c). The species number of forest specialist spider was significantly higher in the suburban area than in the rural and urban ones ($\chi^2 = 26.0006$; $df = 2{,}3$; $p < 0.001$, Fig. 1d). The number of xerophilous species was significantly higher in the urban sites than in the rural and suburban ones ($\chi^2 = 43.0912$; $df = 2{,}3$; $p < 0.001$, Fig. 2a). The species number of light-preferring spider species was significantly higher in the urban area than in the rural area ($\chi^2 = 13.5226$; $df = 2{,}3$; $p < 0.001$, Fig. 2b).

Two of the five most abundant species were forest specialist species (*D. concolor*, *P. alacris*), two were generalist species (*O. praticola*, *T. terricola*) and one was open-habitat species (*T. pedestris*). One of the two forest specialist species (*D. concolor*) was more abundant in the rural areas than in the suburban and urban ones ($\chi^2 = 300.3505$; $df = 2{,}3$; $p < 0.001$, Fig. 3a). The other forest species (*P. alacris*) was most numerous in the suburban sites ($\chi^2 = 28.6329$; $df = 2{,}3$; $p < 0.001$, Fig. 3b). The generalist species showed significant variation along the urbanization gradient. *O. praticola* was more abundant in the urban area, compared to the rural and suburban sites ($\chi^2 = 45.9617$; $df = 2{,}3$; $p < 0.001$, Fig. 3c), while the number of individuals of *T. terricola* increased continuously from the rural area to the urban sites ($\chi^2 = 82.3959$; $df = 2{,}3$; $p < 0.001$, Fig. 3d). The open-habitat species (*T. pedestris*) was more numerous

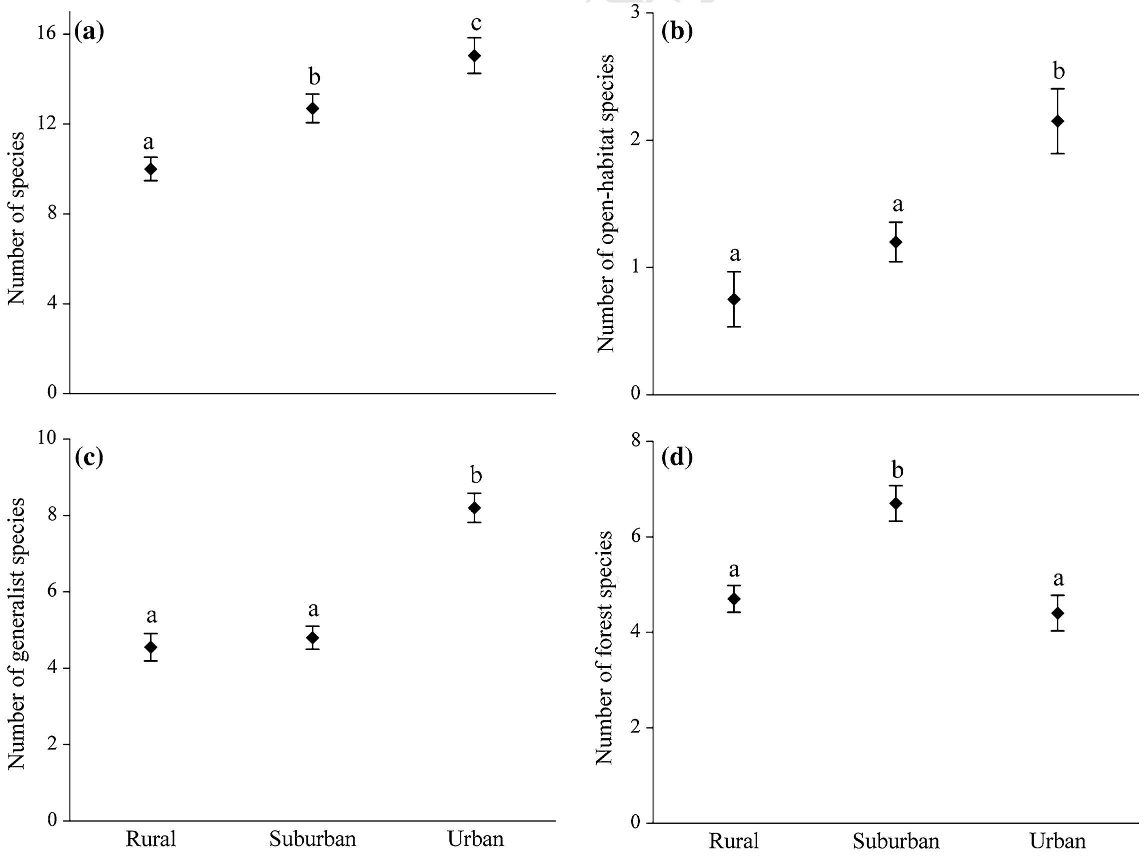

Fig. 1 Average values of overall species (**a**), open-habitat species (**b**), generalist species (**c**), and forest spider species richness (**d**) (±SE) along the studied urbanization gradient for the pitfall traps. *Different letters* indicate significant differences by Tukey test ($p < 0.05$)

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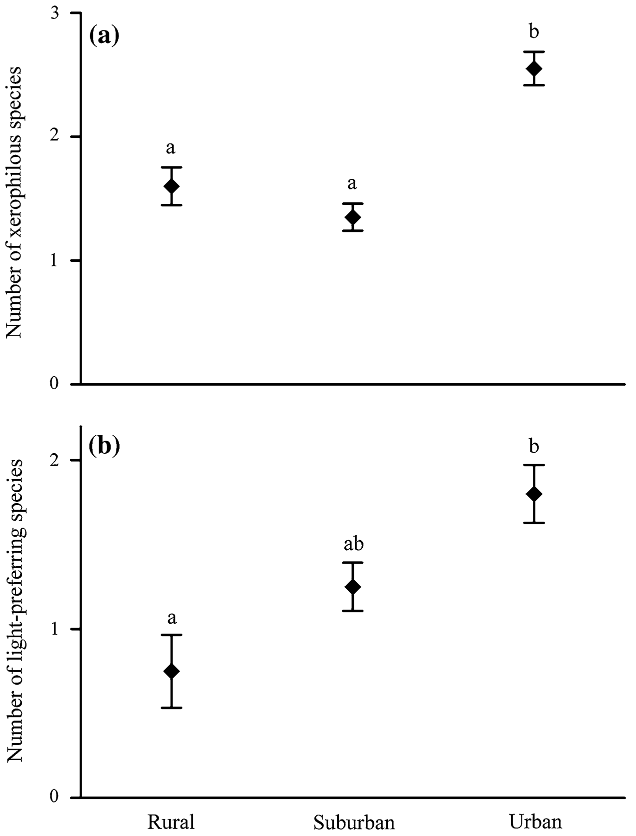

Fig. 2 Average values of xerophilous species (**a**) and light-preferring species richness (**b**) (±SE) along the studied urbanization gradient for the pitfall traps. *Different letters* indicate significant differences by Tukey test ($p < 0.05$)

in the urban sites than in the suburban and rural sites ($\chi^2 = 47.4325$; $df = 2,3$; $p < 0.001$, Fig. 3e).

The DCCA triplot showed that there was a clear separation among the traps along the rural–urban gradient based on the number of individuals of the five most frequent species. The rural traps differed from the suburban and urban traps, which were more similar to each other. The rural traps are located on the right part, whereas the suburban and urban traps on the left part of the ordination scatter-plot. The suburban and urban traps separated along the second axis of the ordination scatter-plot (Fig. 4). Furthermore, the rural sites characterized by higher amounts of decaying wood material and higher cover of herbs. The suburban sites disposed of higher relative humidity and cover of leaf litter and shrubs. The urban sites had higher ground and air temperature and lower canopy cover. The triplot graph also demonstrated that *D. concolor* was associated with the rural sites of higher amounts of decaying wood and more herbs. *P. alacris* favored the moderate disturbed suburban sites with higher cover of leaf litter and higher relative humidity. Three species (*O. praticola*, *T. terricola*, and *T. pedestris*) were characteristic to urban sites with higher ground, air temperature, and lower canopy cover.

Discussion

Our results showed that there were significant effects of urbanization on ground-dwelling spider assemblages, as the intensity of disturbance increase from the rural sites to the urban ones. Besides the four classical hypotheses, we also studied two novel hypotheses. We pointed out that the overall species richness increased from the rural area to the urban one; therefore, this result did not support the increasing disturbance hypothesis. Richness of the open-habitat and the generalist species were the highest in the urban sites, supporting the matrix and opportunistic species hypotheses. Species richness of the forest specialist spiders was the highest in the suburban sampling sites, contradicting the habitat specialist hypothesis. Our results verified the two new hypotheses, because the species richness of both the xerophilous and light-preferring species were the most numerous in the urban area. Analyzing the abundance of the most frequent spider species supported the matrix species, the opportunistic species and the habitat specialist hypothesis, too. As the frequent open-habitat and generalist species were significantly more numerous in the urban area, while the most abundant forest specialist spider species were significantly more abundant in the less disturbed areas (in the rural or in the suburban area).

Alaruikka et al. (2002) studied ground-dwelling spiders along a rural–urban forest gradient in Finland, but they did not find any significant differences in overall species richness, while Magura et al. (2010b) showed that the total number of spider species was significantly higher in the urban area than in the suburban and rural area in Hungary. Our results, and those of Alaruikka et al. (2002) and Magura et al. (2010b), showed that the increasing disturbance hypothesis was not supported; moreover, we found that the overall species richness increased significantly from the rural sites to the urban ones. A possible explanation for the lack of support of the increasing disturbance hypothesis may be that because of urbanization the habitat patches are enormously diverse in the urban area. Patches with more open canopy layer, moderately closed patches, and fully closed forest patches appear simultaneously in the urban area. Less and moderately closed patches may be more suitable for the open-habitat and generalist species. They can easily colonize these patches, increasing the diversity in the urban area. Furthermore, in the urban forest patches, edge-like habitats may appear, which modify significantly species patterns (Lövei et al. 2006). Several studies that investigated spiders in forests with different levels of disturbance found that overall species richness did not differ significantly among the studied sites, but the species composition changed along the gradient (Chen and Tso 2004; Hsieh et al. 2003; Ulrich et al. 2010). The studies of other taxa (for ground beetles: Magura et al. 2004; for isopods: Hornung et al. 2007) in Debrecen showed differences from our investigation. Hornung et al. (2007) did not find significant differences

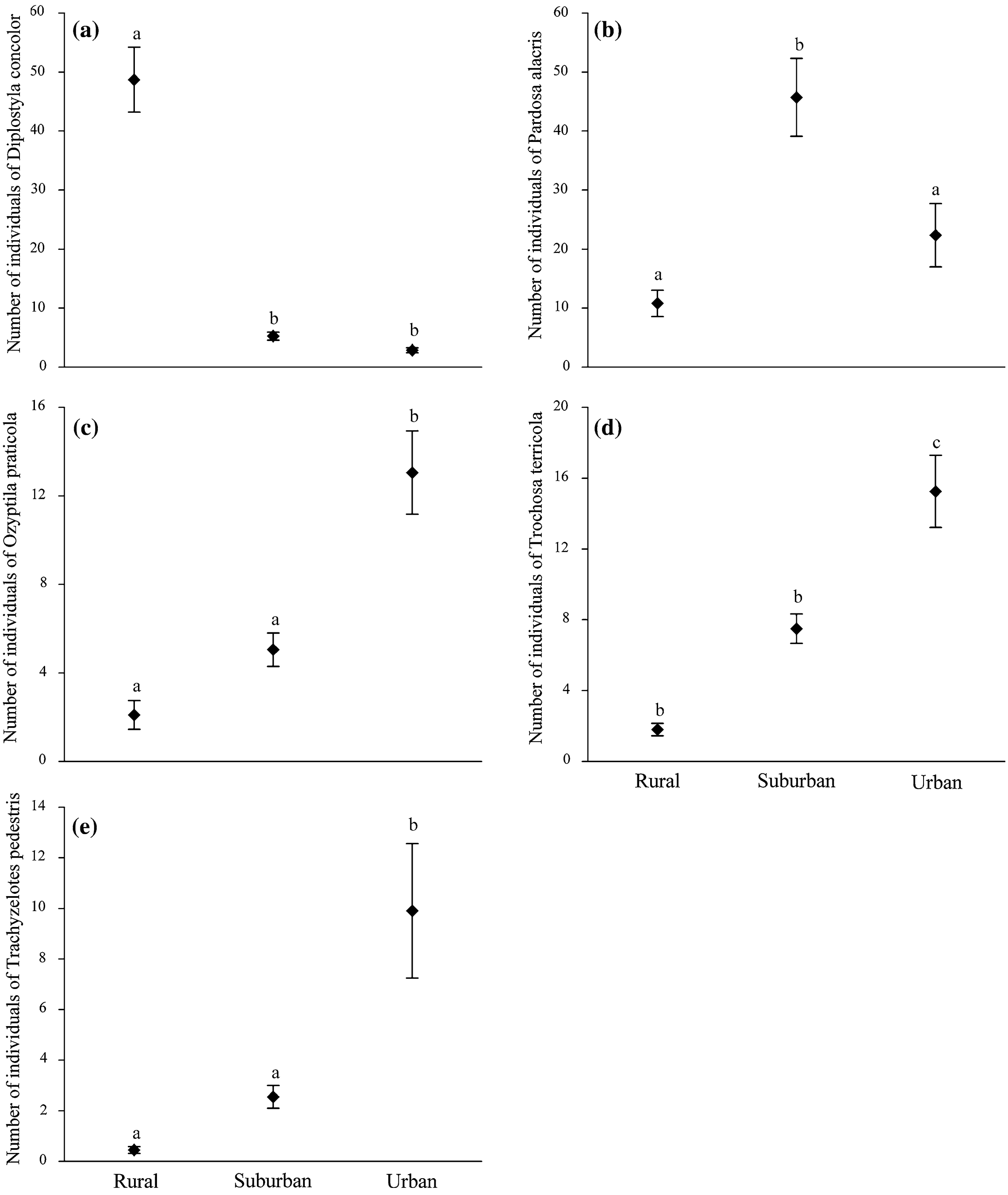

Fig. 3 Average number of individuals of *Diplostyla concolor* (forest species) (**a**), *Pardosa alacris* (forest species) (**b**), *Ozyptila praticola* (generalist species) (**c**), *Trochosa terricola* (generalist species) (**d**) and *Trachyzelotes pedestris* (open-habitat species) (**e**) (±SE) along the studied urbanization gradient for the pitfall traps. *Different letters* indicate significant differences by Tukey test ($p < 0.05$)

in overall isopod species richness along the disturbance gradient, while Magura et al. (2004) pointed out that the number of carabid beetle species was significantly higher in the rural and urban area than in the suburban one. These results reveal that the different groups of arthropods may respond differently to the urbanization at the same area.

Our results supported the matrix species hypothesis, as the species richness of the open-habitat species was higher in the urban sampling sites than in the suburban and urban ones. The urban park differed significantly from the suburban and rural forested sites, because these fragments are the most open and the warmest. From the surrounding matrix, several open-habitat species can penetrate. The heavily disturbed urban forest patches have higher air and ground surface temperature; therefore, in these sites there are favorable microhabitats where open-habitat species can survive. Matveinen and

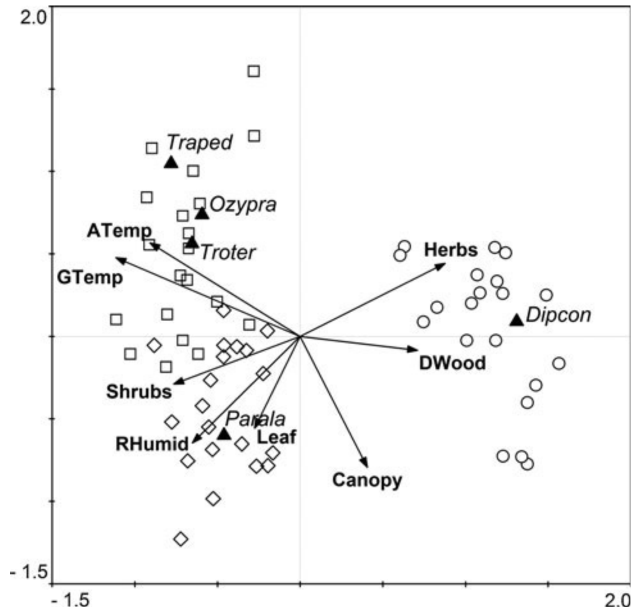

Fig. 4 DCCA for the five frequent spider species where the number of individuals made up at least 5 % of the total catch. *Empty symbols* represent the pitfall traps (*squares* urban traps, *rhombuses* suburban traps, *circles* rural traps). The *arrows* denote the increase of the value of the eight environmental variables (*GTemp* ground temperature at 2-cm depth, *ATemp* air temperature on the surface, *RHumid* relative humidity on the surface, *Leaf* cover of leaf litter, *DWood* cover of decaying wood material, *Herbs* cover of herbs, *Shrubs* cover of shrubs, *Canopy* cover of canopy layer). *Filled triangles* and the *six-letter abbreviations* indicate the species (e.g., Dipcon, *Diplostyla concolor*)

Koivula (2008) showed that the most drastic logging methods (clear-cutting and retention felling) increased the abundance of open-habitat spider species in a Finnish boreal forest, as these forest patches became more open. The results of Magura et al. (2008b) were very similar to our results, because the species number of open-habitat carabid beetle was the highest in the urban park in Debrecen.

In accordance with the opportunistic species hypothesis, the species richness of the generalist species were the highest in the urban sites compared to the suburban and rural ones. Generalist species are able to benefit from the high level of disturbance, and they easily colonize the habitat patches modified by urbanization. The Finnish (Alaruikka et al. 2002) and earlier Hungarian results (Magura et al. 2010b) did not support this prediction, because there was no significant difference in the number of generalist species along the urbanization gradient. The tendency was similar in case of carabid beetles in Debrecen, as there were no significant differences in the number of generalist species among the differently disturbed sites (Magura et al. 2008b).

In our study, the number of forest specialist spider species was the highest in the suburban habitat, contradicting the habitat specialist hypothesis. These spiders prefer the shadier and more humid sites. In the last several years, the rural sites became drier and more open, therefore the cover of shrubs and the relative humidity was the highest in the suburban area. Thus, it is not surprising that the species richness of the forest spiders was statistically higher in these sites. In the present situation, the extent of the disturbance in the rural and the suburban area may be not so significantly different. Therefore the spatial distribution and the richness of the forest specialist spiders were rather influenced by the environmental conditions (shadier and moister conditions) than by the level of the disturbance.

The xerophilous species hypothesis predicts that the dominance of xerophilous species would increase from the rural area to the urban one. Our investigation supported this prediction because the number of xerophilous species was higher in the urban sites than in the suburban and rural sites. The urban forest fragments were more open than the suburban and rural fragments, therefore the ground surface and air temperature were the highest in the city center. Due to this process, the dominance of the xerophilous species was the highest in the urban habitat type. Hoffmann and Andersen (2003) pointed out that the hot climate specialist ant species preferred the open habitats, as the temperature is higher in these sites. Menke et al. (2011) assessed that the native ant species that prefer the warmer and drier sites occurred in a higher number in the open habitats.

Our result corroborated the light-preferring species hypothesis, as the species richness of light-preferring species increased from the rural sites to the urban ones. The species richness was the highest in the urban park. The forest fragments of the urban area were more open; this resulted in a higher light value than in the suburban and urban forests. In the urban forest patches with lighter conditions, light-preferring species found their favorable microhabitats and they can also colonize here. Lütolf et al. (2009), studying butterflies, also showed that dry grassland butterfly species favored the forest patches with more open canopy, and their abundance decreased as the canopy closure increased.

Our results showed that urbanization affected the distribution of all frequent species. DCCA pointed out that the rural sites differed from the suburban and urban sites, while the suburban and urban sites were quite similar to each other. Each of the frequent forest specialist species (*D. concolor* and *P. alacris*) responded significantly to urbanization. *D. concolor* occurred in lower number in the urban and suburban sites than in the rural sites, while *P. alacris* was the most frequent in the suburban area. *D. concolor* occurred in high number only in the rural sites with higher amounts of decaying woods and more herbs. *P. alacris* prefers the relatively dry and shady sites with high amount of leaf litter (Vlček 1995). The suburban habitat was the shadiest and it had the thickest leaf litter among the studied sites. The number of individuals of the two generalist species (*O. praticola* and *T. terricola*) (Buchar and Ruzicka 2002) increased continuously from the rural areas to the urban ones. The number of individuals of *T. pedestris*, which is a typical open-habitat species

(Buchar and Ruzicka 2002) increased from the rural sites to the urban ones, too. It seems that these species prefer the more open and drier sites with higher air and ground surface temperature; therefore, they occurred in the highest number in the urban habitat type.

Our result showed that the overall species richness is not suitable indicator of human disturbance along the urbanization gradient. To investigate the urbanization processes based on overall diversity, the consequence would be that the urbanization is useful for the spider assemblages, as the species richness increased continuously from the rural sampling sites to the urban ones. The reason for this is that the number of the less disturbance-sensitive open-habitat and generalist species increased towards the urban habitat because these spiders could penetrate from the matrix habitats. The number of xerophilous and light-preferring species also increased from the rural sites to the urban sites, as the urban forest patches are more open than the suburban and rural ones. The forest specialist spider species occurred in higher number only in the less disturbed contiguous rural and/or suburban forest patches. The population size of these species decreased towards the more isolated urban patches because these patches are too small for the spiders to be able to settle down permanently. Thus, these species can survive and reproduce with major chance in the natural forest patches.

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