Linden Trees are Favourable Host Plants for Phytoseiid Generalists in Urban Environments

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Abstract

The assemblages of phytoseiid mites on the leaves of *Tilia cordata* and *T. platyphyllos* planted in heterogeneous urban habitats were studied. Six phytoseiid species, namely, *Euseius finlandicus*, *E. gallicus*, *Neoseiulella tiliarum*, *N. aceri*, *Paraseiulus talbii*, and *Typhlodromus* (*Typhlodromus*) *pyri*, were found on the studied linden leaves.

The results indicate that both *T. cordata* and *T. platyphyllos* may serve as favourable host plants for the generalists *E. finlandicus* and *N. tiliarum* in urban environments. Both generalist predatory species preferred sheltered leaf microhabitats.

The first record of *E. gallicus* in central Europe and the consistent occurrence of other phytoseiid species on the surveyed linden trees confirm the important role of urban greenery in landscape biodiversity.

Keywords: *Tilia*, Acari, Phytoseiidae, *Euseius gallicus*, leaf microhabitat, urban greenery

Introduction

Urban nature plays a crucial role in the standard of living within cities and contributes importantly to quality of life in our increasingly urbanized society in many ways (Chiesura 2004, Miller 2005). Urban parks and forests often include diverse woody vegetation, partly introduced but also native and such vegetation serves as nourishment, shelter, and substrate to a wide variety of animals (Brown and Freitas 2002). Arthropods are a dominant component of biodiversity in terrestrial ecosystems (Yang and Gratton 2014, Ebeling et al. 2018), and most studies dealing with arthropods in urban environments are focused mainly on insects rather than on other terrestrial arthropods (McIntyre 2000).

Urban greenery is affected by a number of unfavourable natural and anthropogenic stressors. Herbivorous arthropods can directly reduce the standing biomass of plants through the consumption of plant tissue, and alternatively, by consuming seeds, they can indirectly influence plant community composition by reducing the success of seed-limited plant species without directly damaging plants (Maron and Simms 1997, Ebeling et al. 2018). At higher trophic levels, carnivores and omnivores can control herbivore communities by regulating their density and composition (Ebeling et al. 2018). Many phytoseiid mites inhabiting trees are important predators of various small arthropods, especially phytophagous mites, and in natural habitats, some phytoseiids also play an important role in preventing outbreaks of various phytophagous mites (Edland and Evans 1998, McMurtry et al. 2013). Knowledge on the phytoseiid mite taxocenoses occurring on trees planted in urban areas has been fragmentary. Several phytoseiid species have been reported on ornamental trees and shrubs grown in various urban localities in Hungary (Ripka et al. 2013, Kontschán et al. 2014) and Texas (Ehler and Frankie 1979). According to Kropczynska et al. (1985), the abundance of phytoseiids can be high in urban areas. In general, urban phytoseiid fauna assemblages are less known than phytoseiid fauna of orchards or vineyards; thus, the aim of this study is to investigate the species composition of phytoseiid mites on the leaves of two *Tilia* species commonly grown in heterogeneous urban environments. Additionally, the intra-leaf distribution of the most frequently occurring phytoseiid species found on investigated trees is reported. Both *Tilia cordata* Miller and *T. platyphyllos* Scopoli are widely used for shade and ornamental purposes in streets, alleys, public forests and parks, and other urban spaces, and knowledge regarding the phytoseiid assemblages on these commonly planted tree species can contribute to a better understanding of the role of phytoseiids on trees in an urban environment.

Material and Methods

The field study was carried out at five sites within the city of Prague. The sites Patockova (50°5’9.879”N, 14°22’7.225”E, 300 m a.s.l.) and Pod Kralovkou (50°5’11.068”N, 14°22’41.754”E, 285 m a.s.l.) were streets with high car traffic intensity (approximately forty thousand and fifteen thousand vehicles per day, respectively) with monospecific tree rows composed of *T. cordata* planted in turf strips very close to the roadways. The site U Kruhovky (50°7’54.225”N, 14°22’40.634”E, 275 m a.s.l.) was street with low car traffic intensity in residential areas with *T. platyphyllos* trees planted in turf strips very close to the roadway. The site Obora Hvezda (50°4’58.336”N, 14°19’39.759”E, 365 m a.s.l.; its area is approximately 86 ha) is a city park consisting of a predominantly mixed forest composed of mainly autochthonous forest tree species [e.g., *Acer platanoides* L., *Carpinus betulus* L., *Fagus sylvatica* L., *Quercus petraea* (Mattuschka) Lieblein, *Picea abies* (L.) Karsten, *Pinus sylvestris* L.] touched by standard forestry practices. A row of *T. platyphyllos* trees growing at the forest edge near the mown lawn in the central part of this park located on the western outskirts of the city was monitored at this site. The site Letenske sady (50°5’48.567”N, 14°25’14.260”E, 230 m a.s.l.; its area is approximately 46 ha) is an intensively managed municipal park near the city centre with mown lawns, flowerbeds and abundantly planted native and less frequently planted non-native angiosperms (e.g., *A. platanoides* L., *A. campestre* L., *Aesculus hippocastanum* L., *Castanea sativa* Miller, *Catalpa bignonioides* Walter, *Corylus colurna* L., *Liriodendron tulipifera* L., *Platanus* × *hispanica* Miller ex Münchhausen, *Quercus robur* L., *T. cordata*, *T. platyphyllos*) and infrequently planted gymnosperms (e.g., *Ginkgo biloba* L., *Pinus mugo* Turra, *P. nigra* Arnold, *Taxus baccata* L.). Both *T. cordata* and *T. platyphyllos* trees were monitored at this site.

Leaf samples were taken from the same 10 randomly selected trees per linden species (approximately more than 50 years old) over two seasons (2016 and 2017) at the sites Patockova, Pod Kralovkou, U Kruhovky, and Obora Hvezda. At the site Letenske sady, the leaf samples were taken from the same five randomly selected trees per linden species within 2017. The sampling dates on the studied sites are listed in Table 1. The standard sample size was 10 randomly selected leaves of approximately the same size from each tree, collected from the proximal part of the shoots. Each sample was immediately placed in a plastic bag and stored in a cold-storage box. Sampled leaves were brought to the laboratory, where they were either examined immediately or stored in the refrigerator at 5 °C for < 48 h before examination. Cooled leaves were inspected individually under a binocular microscope. The entire leaf surface was surveyed, and the mites found were mounted on slides in lactic acid. Immature phytoseiid stages were not determined and were excluded from analyses. The intra-leaf positions of the phytoseiid mites on the linden leaves were studied with leaf samples from five trees per linden species per site (Patockova, Pod Kralovkou, U Kruhovky, and Obora Hvezda); those leaves were collected and examined in the year of the last collection date (number IV/Table 1). The standard sample size remained identical to previous ones, but the single collected leaf (for a total of 100 leaves per linden species) was immediately placed in a separate plastic bag. The undersides of these leaves were divided into three microhabitats – domatia, veins, and the leaf blade remaining between veins. The mites occurring near the domatia (veins) within a distance of twice the body length of a mite were included in the domatia (vein) microhabitat. The positions and numbers of motile stages of phytoseiid species per leaf microhabitat were recorded. The phytoseiids were classified based on the keys of Chant and Yoshida-Shaul (1982, 1987, 1989), Chant and McMurtry (2007) and Tixier et al. (2010) for *Euseius*. The nomenclature of phytoseiid species used in this study follows Demite et al. (2018). The tree species were identified using the key by Kubat et al. (2002).

Table 1. The sampling dates on *Tilia* spp., Prague

Site	2016			2017			
	I	II	III	I	II	III	IV
Obora Hvezda	30/6	20/7	31/8	30/5	27/6	3/8	23/8
U Kruhovky	22/6	19/7	5/9	12/6	20/7	14/8	31/8
Letenske sady	--	--	--	11/6	17/7	17/8	12/9
Patockova Pod Kralovkou	27/6	25/7	29/8	4/6	9/7	6/8	27/8

Dominance (Do) determines the percentage of specimens of a given taxon in the total number of mites collected from a given linden species at each study site. The species dominance is characterized by the following scale: eudominant (≥ 10%), dominant (5–9.99%), subdominant (2–4.99%), recedent (1–1.99%) and subrecedent (< 1%) (Tischler 1965). The constancy of occurrence (Co) indicates the relationship between the number of samples in which a given species occurred and the total number of samples collected from a given linden species at each study site. The following categories of constancy were used: euconstant (76–100%), constant (51–75%), accessory (26–50%) and accidental (≤ 25%) species (Tischler 1965). Transformation of the data was insufficient to normalize the data for a parametric analysis of variance (ANOVA). Therefore, differences among sites and phytoseiid species in abundances of mites per leaf and differences among phytoseiid locations in counts of mites per leaf microhabitat were compared via the nonparametric Kruskal-Wallis and multiple comparisons tests. The statistical significance was tested at $P = 0.05$. All statistical analyses were performed using the Statistica 12.0 program package (StatSoft, Inc. 2016).

Results

The phytoseiid species were present in various abundances on all the surveyed linden trees. A total of 3,410 adults of phytoseiid mites belonging to the following six species were found on *Tilia* spp.: *Euseius finlandicus* (Oudemans), *E. gallicus* Kreiter and Tixier, *Neoseiulella tiliarum* (Oudemans), *N. aceri* (Collyer), *Paraseiulus talbii* (Athias-Henriot), and *Typhlodromus* (*Typhlodromus*) *pyri* Scheuten (Table 2). The vast majority of phytoseiid specimens (99.6%) were recorded on the abaxial leaf area. Only 0.94% of leaf samples were without phytoseiid mites. The numbers of phytoseiids on the leaves of *T. platyphyllos* (*T. cordata*) averaged 1.17 (0.96) mites per leaf. For both *T. platyphyllos* and *T. cordata*, the numbers of mites per leaf differed significantly among the sites ($H = 25.62$, $df = 2$, $P < 0.05$ and $H = 12.63$, $df = 2$, $P < 0.05$, respectively) (Table 3). Two species, *E. finlandicus* and *N. tiliarum* (either singly or together), were predominant on both linden species at all sites and composed the majority of the phytoseiids collected from the surveyed linden leaves (99.5% of all sampled phytoseiids).

Table 2. Numbers of detected phytoseiid mites on linden species, Prague (n = phytoseiids/100 leaves)

Species	Site	2016			2017				Total (%)	Co (%)	Do
		I	II	III	I	II	III	IV			
Tilia platyphyllos											
E. finlandicus	A	76	85	58	39	87	95	80	98.86	98.57	ED
	B	27	30	35	45	49	38	38	22.80	81.43	ED
	C	–	–	–	38^{*}	$39^{\#}$	$22^{\#}$	$40^{\#}$	70.56	73.68	ED
N. tiliarum	A	0	1	1	0	1	3	0	1.14	7.14	R
	B	42	126	184	48	66	161	259	77.11	100	ED
	C	–	–	–	4^{*}	$4^{\#}$	$12^{\#}$	$29^{\#}$	24.87	63.16	ED
T. (*T.*) *pyri*	B	0	0	0	1	0	0	0	0.09	1.43	SR
	C	–	–	–	0^{*}	$1^{\#}$	$0^{\#}$	$0^{\#}$	0.51	5.26	SR
E. gallicus	C	–	–	–	0^{*}	$2^{\#}$	$0^{\#}$	$5^{\#}$	3.55	26.32	SD
N. aceri	C	–	–	–	1^{*}	$0^{\#}$	$0^{\#}$	$0^{\#}$	0.51	5.26	SR
Tilia cordata											
E. finlandicus	E	175	57	48	210	94	52	71	88.15	100	ED
	D	93	68	52	114	88	60	67	92.02	100	ED
	C	–	–	–	$41^{\#}$	$42^{\#}$	$16^{\#}$	$27^{\#}$	85.71	80	ED
N. tiliarum	E	9	12	13	15	7	7	27	11.22	71.43	ED
	D	5	6	6	3	5	13	9	7.98	54.29	DM
	C	–	–	–	$3^{\#}$	$5^{\#}$	$6^{\#}$	$7^{\#}$	14.29	65	ED
P. talbii	E	0	2	0	0	0	1	2	0.62	5.71	SR

n^{*} = phytoseiids/40 leaves, $n^{\#}$ = phytoseiids/50 leaves, I – IV = sampling dates, A – Obora Hvezda, B – U Kruhovky, C – Letenske sady, D – Patockova, E – Pod Kralovkou, Co – constancy, Do – dominance, ED – eudominant, DM – dominant, SD – subdominant, R – recedent, SR – subrecedent

Neoseiulella tiliarum was the most common phytoseiid species on the surveyed linden trees; it represented 50.3% of the total phytoseiid abundance, and the numbers of specimens per leaf of *T. platyphyllos* differed significantly among the sites ($H = 37.63$; $df = 2$, $P < 0.05$), dropping from 1.25 mites per leaf at U Kruhovky to 0.008 mite per leaf at Obora Hvezda (Table 3). Eudominant and euconstant *N. tiliarum* was the prevalent phytoseiid species on the leaves of *T. platyphyllos* at U Kruhovky, while it was a recedent and accidental phytoseiid species on *T. platyphyllos* at Obora Hvezda, where *E. finlandicus* was dominant. The abundance of *N. tiliarum* per leaf of *T. cordata* differed significantly ($H = 8.48$, $df = 2$, $P < 0.05$) among the sites (Table 3), whereas its occurrence on *T. cordata* was constant among all sites (Table 2). Significantly more specimens of *N. tiliarum* ($H = 31.65$, $df = 2$, $P < 0.05$) were captured within the well-developed

Table 3. Qualitative and quantitative survey data of phytoseiid mites on *Tilia* spp., Prague (mean ± SEM)

Tilia cordata			
Species	Site		
	Patockova	Pod Kralovkou	Letenske sady
*E. finlandicus**	0.766 ± 0.054^{aA}	1.000 ± 0.058^{aB}	0.630 ± 0.200^{aAB}
*N. tiliarum**	0.081 ± 0.016^{bA}	0.127 ± 0.013^{bB}	0.105 ± 0.022^{abAB}
P. talbii	0^{c}	0.007 ± 0.003^{c}	0^{b}
Total	0.832 ± 0.057^{A}	1.134 ± 0.060^{B}	0.735 ± 0.194^{AB}

Tilia platyphyllos			
Species	Site		
	Obora Hvezda	U Kruhovky	Letenske sady
*E. finlandicus**	0.741 ± 0.047^{aA}	0.366 ± 0.118^{aB}	0.722 ± 0.266^{aAB}
E. gallicus	0^{b}	0^{b}	0.038 ± 0.012^{ab}
N. aceri	0^{b}	0^{b}	0.005 ± 0.005^{b}
*N. tiliarum**	0.008 ± 0.003^{bA}	1.254 ± 0.128^{aB}	0.257 ± 0.036^{abAB}
T. (*T.*) *pyri*	0^{b}	0.001 ± 0.001^{b}	0.005 ± 0.005^{b}
Total	0.750 ± 0.047^{A}	1.621 ± 0.118^{B}	1.027 ± 0.267^{AB}

SEM is standard error of the mean; significant differences among the phytoseiid species (sites analysed for two prevalent species marked with *) are highlighted with small letters in column (capital letters in rows) based on Kruskal-Wallis test, $P < 0.05$

domatia created by overlapping trichomes in the vein axils and near the raised hairy veins on the underside of leaves of *T. platyphyllos*, and all specimens of *Neoseiuella tiliarum* were detected within the similar sheltered leaf tuft domatia microhabitat on the abaxial leaf area of *T. cordata* (Table 4). The vast majority of specimens of *Neoseiuella tiliarum* sheltered more deeply within the domatia and persisted within the protected leaf domatia and vein microhabitats when they were repeatedly disturbed. *Neoseiuella tiliarum* moved relatively slowly and relocated with obvious reluctance on the surface of the surveyed leaves of both *Tilia* spp., even when they were disturbed during inspection of the leaves.

Table 4. The predominant phytoseiid species per leaf microhabitats (mean ± SEM)

Microhabitat	*T. platyphyllos*		*T. cordata*	
	N. tiliarum	*E. finlandicus*	*N. tiliarum*	*E. finlandicus*
domatia	1.01 ± 0.19 ^{a}	0.30 ± 0.06	0.21 ± 0.05	0.63 ± 0.08 ^{a}
veins	0.61 ± 0.14 ^{a}	0.21 ± 0.06	0	0.12 ± 0.04 ^{b}
leaf blade	0.05 ± 0.03 ^{b}	0.11 ± 0.03	0	0.06 ± 0.02 ^{b}

SEM is standard error of the mean, $^{a\text{-}b}$ is significant differences among the leaf microhabitat (in column), Kruskal-Wallis test, $P < 0.05$

Euseius finlandicus was the second most abundant phytoseiid species, accounting for 49.2% of the phytoseiid fauna studied herein. Euconstant *E. finlandicus* dominated on the leaves of *T. cordata* at all sites (89.4% of all sampled phytoseiids on *T. cordata*), and it was also the prevalent species on *T. platyphyllos* trees at two sites (Table 2). *Euseius finlandicus* abundance per *T. cordata* leaf differed significantly among the sites ($H = 10.11$, $df = 2$, $P < 0.05$), dropping from 1.0 mite per leaf at Pod Kralovkou to 0.6 mite per leaf at Letenske sady (Table 3). Similarly, the counts of *E. finlandicus* pear leaf of *T. platyphyllos* differed significantly ($H = 18.10$, $df = 2$, $P < 0.05$) among sites (Table 3), and two similar categories of constancy of this phytoseiid species on *T. platyphyllos* trees were recorded at the studied sites (Table 2). Although the numbers of *E. finlandicus* specimens were slightly higher within the sheltered leaf domatia and vein microhabitats on the leaves of *T. platyphyllos*, they were not statistically significant ($H = 6.55$, $df = 2$, $P \geq 0.29$) from the numbers on unprotected leaf blade microhabitat. In contrast, specimens of *E. finlandicus* were significantly more abundant ($H = 58.46$, $df = 2$, $P < 0.05$) within the leaf tuft domatia microhabitat on the examined leaves of *T. cordata* (Table 4). Specimens of *E. finlandicus* occurring outside of domatia moved easily and rapidly on the glabrous leaf surface of *T. cordata* leaves when disturbed, but their locomotion on moderately hairy leaves of *T. platyphyllos* was less easy. Most specimens of *E. finlandicus* quickly left the sheltered leaf microhabitat immediately after the first disturbance.

The number of phytoseiid species found on a single linden tree ranged from one to four. *Tilia platyphyllos* was the tree species with higher phytoseiid species diversity. On this tree species, a total of five phytoseiid species were recorded (Table 3), among which *E. gallicus* was detected in the Czech Republic for the first time; in total, this accessory species sporadically recorded in some leaf samples was found at one site and represented only 0.4% of phytoseiid abundance on the surveyed leaves of *T. platyphyllos*. The remaining accidental phytoseiid species were collected rarely and in small numbers (Table 2).

Discussion

Phytoseiid mites were found in different numbers on the leaves of all inspected *Tilia* spp. trees planted in various types of urban habitats. Phytoseiids were recorded abundantly on the surveyed leaves of linden trees planted close to the roads. This is in accordance with the findings of Kropczynska et al. (1985), who recorded no decline in the abundance of phytoseiid mites on trees in streets compared to trees in parks and natural habitats. It seems that streets lined with linden trees can constitute favourable habitat niches enabling the survival and long-term persistence of some phytoseiid species in highly urbanized areas. The majority of sampled individuals belonged to the two phytoseiid species, *N. tiliarum* and *E. finlandicus,* that were clearly dominant on the leaves of *T. platyphyllos* and *T. cordata*. *Euseius finlandicus* is primarily a pollen feeder, and both phytoseiid species mentioned above have been classified as generalist predators with a wide range of foods (McMurtry et al. 2013). The frequent and common occurrence of *N. tiliarum* and *E. finlandicus* on the surveyed leaves of both *Tilia* spp. planted in various types of urban habitats can indicate the favourability of the inspected linden species to serve as host plants for these generalist phytoseiids. According to Niemelä et al. (2002), the urban environment may be unfavourable to specialist coleopteran species. Similarly, the linden trees planted in urban environments may be less favourable host plants for phytoseiid specialists.

It is known that various leaf structures and microhabitats, rather than food availability, may greatly limit the numbers and species diversity of foliar phytoseiid mites on plants (Karban et al. 1995, Schmidt 2014). Leaves of both studied *Tilia* spp. are non-uniform in leaf morphology and traits (Piggot 1969, Kubat et al. 2002); however, the presence of differently structured domatia microhabitats on their leaves is common. *Neoseiulella tiliarum* was exclusively found within the leaf domatia microhabitat on the surveyed hairless leaves of *T. cordata* with compact domatia, and it also preferred the sheltered leaf domatia and vein microhabitats on the moderately pubescent leaves of *T. platyphyllos*. The obvious preference for the sheltered leaf microhabitats among *N. tiliarum* detected on both surveyed *Tilia* spp. is consistent with the results obtained from grapevines (Kreiter et al. 2000). *Neoseiulella tiliarum* moved on the inspected leaves relatively slowly and persisted within domatia when disturbed. The frequent occurrence and persistence of slowly moving specimens of *N. tiliarum* on the unprotected leaf surface could be hazardous to them, so they prefer the sheltered leaf microhabitats and use the same shelter-based method of defensive strategy to avoid possible macropredators, similarly to *Neoseiulella aceri* (Collyer) and *Kampimodromus aberrans* (Oudemans) (Kabicek 2005, 2008). *Neoseiulella tiliarum* has been observed on diverse deciduous trees (Chant and Yoshida-Shaul 1989), and both studied *Tilia* spp. can provide appropriate habitat niches for the survival and persistence of this generalist predator in urban areas.

The occurrence of both generalists, *N. tiliarum* and *E. finlandicus*, on the surveyed *T. platyphyllos* was unstable, and their proportional representation greatly differed among sites. Similar variations in the proportional representation of phytoseiid species caused by interspecific competition on oaks planted in various urban habitats were recorded by Ehler and Frankie (1979). According to Schausberger (1997), the high voracity of *E. finlandicus* females preying on heterospecific juveniles may contribute decisively to the local suppression of other phytoseiid species. It seems that both *N. tiliarum* and *E. finlandicus* with different autecology can successfully coexist on *T. platyphyllos* under local field conditions. The prevalent occurrence of *E. finlandicus* on glabrous leaves of *T. cordata* can indicate a higher favourability of *T. cordata* as a host plant for that mite species. Similarly to *N. tiliarum*, *E. finlandicus* preferred domatia microhabitats on the surveyed *T. cordata* leaves, and it moved easily and rapidly over the surveyed glabrous leaf surface of *T. cordata* when disturbed. Clearly, the ability to move quickly is crucial for *E. finlandicus* because its strategy for defence against predators is based on a rapid escape from them (Chant 1959). Therefore, the leaves of *T. cordata* with well-developed domatia can provide suitable microhabitats for shelter and/or rest by *E. finlandicus*, and simultaneously, the glabrous leaf blades can constitute microhabitats with favourable conditions for the implementation of its defensive strategy based on a rapid escape from predators. The generalist *E. finlandicus* is a widespread phytoseiid species on natural and urban vegetation (Schausberger 1997, Grabovska and Kolodochka 2014), and its common occurrence on the leaves of both surveyed *Tilia* spp. confirms its ability to inhabit linden trees grown in various types of urban habitats. The prevalent phytoseiids were commonly detected on the surveyed street and park trees; thus, these natural enemies can potentially realize their important role as environmentally friendly natural control agents of harmful phytophagous mites on trees grown in an urban environment and can thereby positively contribute to ecosystem services.

At only a single site, Letenske sady *E. gallicus* was found several times and considered to be infrequent and subdominant on *T. platyphyllos*. *Euseius gallicus* has been recorded from some countries of north-western and southern Europe and from Tunisia and Turkey on various plants (Tixier et al. 2010, Döker et al. 2014, Demite et al. 2018). The identification of *E. gallicus* on *T. platyphyllos* from a municipal park in Prague and its occurrence in some other European countries indicate its wide distribution in Europe, including Central Europe. The repeated identification of *E. gallicus* on *T. platyphyllos* at the studied site shows that autochthonous tree species in intensively managed urban parks with artificial plant assemblages may serve as host plants for relatively little known acarine species. Thus, municipal parks can contribute considerably to phytoseiid species diversity within urban areas and may also play a very important role in the enhancement of landscape biodiversity.

Conclusions

The results of this study suggest that both *T. cordata* and *T. platyphyllos* planted in urban habitats may serve as semi-natural refuges and favourable host plants for some phytoseiid species. The prevalent phytoseiids on *Tilia* trees grown in heterogeneous urban environments were generalist predators with different local ecology.

The consistent occurrence of several phytoseiid species on the surveyed linden trees confirms the important role of scattered urban greenery for survival and long-term persistence of these natural enemies that can positively contribute to ecosystem services by potentially regulating of some harmful herbivorous arthropods in urban environment.

The first finding of *E. gallicus* in Central Europe and constant occurrence of some other phytoseiid species on park and street linden trees together with the scarcity of knowledge how these mites can respond to changes resulting from urbanization demonstrate the need for further studies of these environmentally friendly natural enemies in urban ecosystems.

References

Brown, Jr., K.S. and Freitas, A.V. 2002. Butterfly communities of urban forest fragments in Campinas, São Paulo, Brazil: Structure, instability, environmental correlates, and conservation. *Journal of Insect Conservation* 6(4): 217–231.

Chant, D.A. 1959. Phytoseiid mites (Acarina: Phytoseiidae). Part I. Bionomics of seven species in southeastern England. Part II. A taxonomic review of the family Phytoseiidae, with descriptions of thirty-eight new species. *The Canadian Entomologist* 91 (Supplement 12): 5–166.

Chant, D.A. and McMurtry, J.A. 2007. Illustrated keys and diagnoses for the genera and subgenera of the Phytoseiidae of the world (Acari: Mesostigmata). Indira Publishing House, West Bloomfield, 220 pp.

Chant, D.A. and Yoshida-Shaul, E. 1982. A world review of the *soleiger* species group in the genus *Typhlodromus* Scheuten (Acarina: Phytoseiidae). *Canadian Journal of Zoology* 60(12): 3021–3032.

Chant, D.A. and Yoshida-Shaul, E. 1987. A world review of the *pyri* species group in the genus *Typhlodromus* Scheuten (Acari: Phytoseiidae). *Canadian Journal of Zoology* 65(7): 1770–1804.

Chant, D.A. and Yoshida-Shaul, E. 1989. A world review of the *tiliarum* species group in the genus *Typhlodromus* Scheuten (Acarina: Phytoseiidae). *Canadian Journal of Zoology* 67(4): 1006–1046.

Chiesura, A. 2004. The role of urban parks for the sustainable city. *Landscape and Urban Planning* 68(1): 129–138.

Demite, P.R., Moraes, G.J. de, McMurtry, J.A., Denmark, H.A. and Castilho, R.C. 2018. Phytoseiidae Database: a website for taxonomic and distributional information on phytoseiid mites (Acari). *Zootaxa*, 3795(5): 571-577. Available online at: http://www.lea.esalq.usp.br/phytoseiidae Last accessed on: January 14, 2018.

Döker, I., Witter, J., Pijnakker, J., Kazak, C., Tixier, M.-S. and Kreiter, S. 2014. *Euseius gallicus* Kreiter and Tixier (Acari: Phytoseiidae) is present in four more countries in Europe: Belgium, Germany, The Netherlands and Turkey. *Acarologia* 54(3): 245–248.

Ebeling, A., Hines, J., Hertzog, L.R., Lange, M., Meyer, S.T., Simons, N.K. and Weisser, W.W. 2018. Plant diversity effects on arthropods and arthropod-dependent ecosystem functions in a biodiversity experiment. *Basic and Applied Ecology* 26: 50–63.

Edland, T. and Evans, G.O. 1998. The genus *Typhlodromus* (Acari: Mesostigmata) in Norway. *European Journal of Entomology* 95(2): 275–295.

Ehler, L.E. and Frankie, G.W. 1979. Arthropod fauna of live oak in urban and natural stands in Texas. II. Characteristics of the mite fauna (Acari). *Journal of the Kansas Entomological Society* 52(1): 86–92.

Grabovska, S.L. and Kolodochka, L.A. 2014. Species complexes of predatory phytoseiid mites (Parasitiformes, Phytoseiidae) in green urban plantations of Uman' (Ukraine). *Vestnik Zoologii* 48(6): 495–502.

Kabicek, J. 2005. Intra-leaf distribution of the phytoseiid mites (Acari, Phytoseiidae) on several species of wild broad-leaved trees. *Biologia* 60(5): 523–528.

Kabicek, J. 2008. Cohabitation and intra-leaf distribution of phytoseiid mites (Acari: Phytoseiidae) on leaves of *Corylus avellana*. *Plant Protection Science* 44(1): 32–36.

Karban, R., English-Loeb, G., Walker, M.A. and Thaler, J. 1995. Abundance of phytoseiid mites on *Vitis* species: effects of leaf hairs, domatia, prey abundance and plant phylogeny. *Experimental and Applied Acarology* 19(4): 189–197.

Kontschán, J., Karap, A. and Kiss, B. 2014. Phytoseiid mites (Acari, Mesostigmata) from the rest areas of Hungarian highways. *Opuscula Zoologica Budapest* 45(1): 25–31.

Kreiter, S., Tixier, M.-S., Auger, P., Muckensturm, N., Sentenac, G., Doublet, B. and Weber, M. 2000. Phytoseiid mites of vineyards in France (Acari: Phytoseiidae). *Acarologia* 41(1-2): 77–96.

Kropczynska, D., Vrie, M. van de and Tomczyk, A. 1985. Woody ornamentals. In: W. Helle and M.W. Sabelis (Eds.): Spider mites, their biology, natural enemies and control. Vol. 1B. Elsevier, Amsterdam, p. 385–393.

Kubat, K., Hrouda, L., Chrtek, J., Kaplan, Z., Kirschner, J. and Stepanek, J. 2002. Klic ke kvetene Ceske republiky. [Key to the flora of the Czech Republic]. Academia, Prague, 928 pp. (in Czech)

Maron, J.L. and Simms, E.L. 1997. Effect of seed predation on seed bank size and seedling recruitment of bush lupine (*Lupinus arboreus*). *Oecologia* 111(1): 76–83.

McIntyre, N. 2000. Ecology of urban arthropods: A review and a call to action. *Annals of the Entomological Society of America* 93(4): 825–835.

McMurtry, J.A., Moraes, G.J. de and Sourassou, N.F. 2013. Revision of the lifestyles of phytoseiid mites (Acari: Phytoseiidae) and implications for biological control strategies. *Systematic and Applied Acarology* 18(4): 297–320.

Miller, J.R. 2005. Biodiversity conservation and the extinction of experience. *Trends in Ecology and Evolution* 20(8): 430–434.

Niemelä, J., Kotze, D.J., Venn, S., Penev, L., Stoyanov, I., Spence, J., Hartley, D. and Oca, E.M. de 2002. Carabid beetle assemblages (Coleoptera, Carabidae) across urban-rural gradients: an international comparison. *Landscape Ecology* 17(5): 387–401.

Piggot, C.D. 1969. The Status of *Tilia cordata* and *T. platyphyllos* on the Derbyshire Limestone. *Journal of Ecology* 57(2): 491–504.

Ripka, G., Szabó, A., Tempfli, B. and Varga, M. 2013. New plant-inhabiting mite records from Hungary (Acari: Mesostigmata, Prostigmata and Astigmata) II. *Acta Phytopathologica et Entomologica Hungarica* 48(2): 237–244.

Schausberger, P. 1997. Inter- and intraspecific predation on immatures by adult females in *Euseius finlandicus*, *Typhlodromus pyri* and *Kampimodromus aberrans* (Acari: Phytoseiidae). *Experimental and Applied Acarology* 21(3): 131–150.

Schmidt, R.A. 2014. Leaf structures affect predatory mites (Acari: Phytoseiidae) and biological control: a review. *Experimental and Applied Acarology* 62(1): 1–17.

StatSoft Inc. 2016. Statistica (data analysis software system). ver. 12. Available online at: www.statsoft.com

Tischler, W. 1965. Agrarökologie [Agroecology]. VEB Gustav Fischer Verlag, Jena, 499 pp. (in German)

Tixier, M.-S., Kreiter, S., Okassa, M. and Cheval, B. 2010. A new species of the genus *Euseius* Wainstein (Acari: Phytoseiidae) from France. *Journal of Natural History* 44(3-4): 241–254.

Yang, L.H. and Gratton, C. 2014. Insects as drivers of ecosystem processes. *Current Opinion in Insect Science* 2: 26–32.