MAPLE TREES – HOST PLANTS FOR SOME PHYTOSEIID MITES

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Phytoseiid mite communities on *Acer pseudoplatanus*, *A. platanoides*, and *A. campestre* were monitored in 2013–2014. Totally 3657 specimens of phytoseiid mites belonging to seven species (*Euseius finlandicus*, *Neoseiulella aceri*, *N. tuberculata*, *Typhlodromus (Typhlodromus) pyri*, *Paraseiulus soleiger*, *P. triporus*, and *Phytoseius echinus*) were found on the examined maple leaves. *N. aceri*, the most common species, was dominant and frequently present on the leaves of both *A. platanoides* and *A. campestre*. The leaves of *A. pseudoplatanus* were favourable habitats for both *E. finlandicus* and *N. tuberculata*. Thus, maple trees may serve as suitable host plants for some native phytoseiid mites, particularly *N. aceri* and *E. finlandicus*.

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INTRODUCTION

Biological control, a widely accepted method of integrated pest management, is usually defined as the suppression of pest populations by the actions of their native or introduced natural enemies (Smith, 1919). These natural enemies constitute an essential component of all general biological control strategies (Eilenberg et al., 2001). Conservation biological control, based on the modification of the environment, is distinguished from other strategies in that natural enemies are not released (Rechcigl, Rechcigl, 1998; Eilenberg et al., 2001; Jonsson et al., 2008; Pell et al., 2010). Phytoseiid mites are important natural enemies of various phytophagous mites and small insects, and they have been widely used in biological control programs (Evans, 1992; Gerson et al., 2003; McMurtry et al., 2013). In natural habitats, some phytoseiid species are important for preventing outbreaks of diverse phytophagous mites (Edland, Evans, 1998). Various wild and cultivated trees and bushes can serve as reservoirs and refuge for phytoseiid species from which these species can migrate into neighbouring biocenoses (Tuovinen, Rokx, 1991; Strong, Croft, 1993; Tixier et al., 1998; Papaioannou-Souliotis et al., 2000; Kreiter et al., 2002; Duso et al., 2004). Aerial dispersal, as a passive method of transport, could be used by the phytoseiid mites to spread and colonize new habitats (Sabelis, Dicke, 1985; Tixier et al., 1998; Jung, Croft, 2001; Gerson et al., 2003). Woody areas that contain suitable host plants for predatory mites may constitute a source of phytoseiid mites (Tixier et al., 1998). The frequent and abundant occurrence of a certain phytoseiid species on the leaves of different trees can indicate host plant suitability. Maple trees are common deciduous trees in Bohemia (Czech Republic); however, data on the host plants of phytoseiid mite species are scarce. Thus, the aim of this study was to investigate the species diversity of phytoseiid mites on the leaves of common maple species. Knowledge regarding the phytoseiid mite communities on deciduous trees can contribute to a better understanding of the role of natural vegetation as potential reservoirs of phytoseiids within the strategy of conservation biological control.

MATERIAL AND METHODS

Phytoseiid mites were collected from the untreated maple species *Acer pseudoplatanus* L., *A. platanoides* L., and *A. campestre* L. Leaf samples were collected from randomly selected peripheral maple trees (approximately 20–60 years old) of a small mixed forest composed primarily of *Acer* spp., *Carpinus betulus*, *Cornus* sp., *Quercus* spp., *Sambucus nigra*, *Sorbus* spp., and *Tilia cordata* near Božtěšice (50º41´N, 14º1´E; acreage ca. 80 ha) and Liteň (49º53´N, 14º7´E; acreage ca. 140 ha) in Bohemia, Czech Republic. The tree species were determined using the key by Kubát et al. (2002). Samples were collected on four dates (22/6, 20/7, 17/8, and 7/9) in 2013 and three dates in 2014 (28/6, 26/7, and 23/8). The same trees (five trees/maple species) were observed at each site on each collection date. The standard sample size was 10 leaves randomly selected from the middle area of the leaf shoot per tree of approximately identical size and age. Leaves with various injuries (chlorosis, galls, and others) were excluded from the sampling. Each sample was immediately placed in a plastic Ziploc bag (20 × 30 cm) and stored in a cold-storage box. Sampled leaves were brought to the laboratory where they were either examined or stored in the refrigerator at 5°C. The leaves were inspected individually using a binocular microscope. The entire leaf surface was surveyed, and mites that were found were mounted on slides in lactic acid. Immature phytoseiid stages were not determined and were excluded from analyses. The phytoseiids were classified based on the keys of Beglyarov (1981a, b), Chant, Yoshida-Shaul (1982, 1987, 1989) and Kanouh et al. (2012). The nomenclature of phytoseiid species used in this study follows Demite et al. (2016).

Dominance (Do) determines the percentage of specimens of a given taxon in the total number of mites collected from a given maple 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%) (Dražina, Špoljar, 2009). The constancy of occurrence (C) shows the relation between the number of samples where a given species occurred and the number of all samples collected from a given maple 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 (Dražina, Špoljar, 2009). Phytoseiid diversity (*d*) was calculated for the different maple species within each site using the Margalef diversity index (Clifford, Stephenson, 1975):

$d = (S - 1)/\ln N$

where:

S = number of species

N = total number of individuals

Abundances of mites on the leaves were evaluated among maple species by the analysis of variance (ANOVA) followed by Tukey's HSD test using the STATISTICA software (Version 12, 2016). Statistical significance was tested at $P = 0.05$. Before carrying out the ANOVA, a logarithmic transformation, i.e. log (y + 1), was applied to the data.

RESULTS

A total of 3657 specimens of phytoseiid mites belonging to the following seven species were found on *Acer* spp.: *Euseius finlandicus* (Oudemans), *Neoseiulella aceri* (Collyer), *N. tuberculata* (Wainstein), *Typhlodromus* (*Typhlodromus*) *pyri* Scheuten, *Paraseiulus soleiger* (Ribaga), *P. triporus* (Chant et Yoshida-Shaul), and *Phytoseius echinus* Wainstein et Arutunjan (Table 1). The Phytoseiidae species were present in different abundances on all the surveyed maple trees. All phytoseiid specimens were recorded on the abaxial leaf area. More phytoseiids were found on the leaves of *A. pseudoplatanus* and *A. platanoides* (81.2% of all sampled phytoseiids) than on the leaves of *A. campestre* ($F = 21.59$; $P < 0.05$). Two species (*N. aceri* and *E. finlandicus*) composed the majority of the phytoseiids collected from the surveyed maple leaves (91.3% of all sampled phytoseiids). *E. finlandicus* was observed in different abundances on the leaves of all surveyed maple species (Table 3) and was the second most abundant species, accounting for 38% of the phytoseiid fauna herein studied. A significantly higher occurrence ($F = 73.49$; $P < 0.05$) of *E. finlandicus* (88.7% of all sampled species specimens) was detected on *A. pseudoplatanus* (an average of 1.8 mites per leaf) (Table 3). *N. aceri* was the most common phytoseiid species; it represented 53.3% of the total phytoseiid abundance, and its occurrence was significantly different among tree species ($F = 310.79$; $P < 0.05$). The majority of *N. aceri* (69.4% of all sampled specimens) were detected on *A. platanoides* leaves (an average of 1.9 mites per leaf). *N. tuberculata*, recorded only on *A. pseudoplatanus* leaves (an average of 0.4 mites per leaf), was the third most abundant species; it accounted for 6.9% of the total phytoseiid abundance. The number of phytoseiid species found on a single maple tree ranged from 3 to 5. The phytoseiid species diversities calculated for different maple species at each site are detailed in Table 2. Moderate fluctuations in *d* values of phytoseiids among maple species were found at both sites.

Table 1. Numbers of detected phytoseiid mites on maple species (*n* = phytoseiids/50 leaves) during 2013 and 2014

	Site	Year 2013				Year 2014			Total (%)	C (%)	Do
		22/6	20/7	17/8	7/9	28/6	26/7	23/8			
Acer platanoides											
E. finlandicus	B	1	5	3	4	2	3	2	2.57	37.14	SD
	L	10	12	10	2	8	16	18	11.13	54.29	ED
N. aceri	B	63	122	150	124	48	106	139	96.78	100	ED
	L	102	115	89	63	54	86	91	87.85	100	ED
P. triporus	B	0	0	3	0	0	0	2	0.64	8.57	SR
	L	0	1	0	0	0	2	1	0.59	8.57	SR
T. (T.) pyri	L	0	3	0	0	0	0	0	0.44	2.86	SR
Acer pseudoplatanus											
E. finlandicus	B	31	73	75	69	36	75	87	73.36	100	ED
	L	69	130	174	171	39	89	115	87.35	100	ED
N. aceri	B	0	2	1	1	0	2	1	1.15	17.14	R
	L	0	2	1	1	0	4	1	1.00	22.86	R
N. tuberculata	B	14	29	37	21	10	21	20	25.00	88.57	ED
	L	8	22	20	9	5	14	21	10.99	65.71	ED
T. (T.) pyri	B	0	1	0	1	0	1	0	0.49	8.57	SR
	L	1	0	2	0	0	0	1	0.44	8.57	SR
Ph. echinus	L	0	1	0	1	0	0	0	0.22	5.71	SR
Acer campestre											
E. finlandicus	B	5	7	8	5	2	10	8	10.56	60.00	ED
	L	0	5	1	3	0	3	4	6.11	25.71	D
N. aceri	B	33	67	73	53	16	58	74	87.79	100	ED
	L	19	22	31	45	16	38	35	78.63	100	ED
P. soleiger	L	1	0	0	0	0	0	0	0.38	2.86	SR
P. triporus	B	0	2	1	0	0	1	3	1.64	17.14	R
	L	0	0	5	5	0	3	1	5.34	22.86	D
T. (T.) pyri	L	0	2	7	3	4	4	5	9.54	25.71	D

C = constancy, Do = dominance, ED = eudominant, D = dominant, SD = subdominant, R = recedent, SR = subrecedent, B = Božtěšice, L = Liteň

Acer platanoides

A total of 1460 specimens of phytoseiid mites belonging to four species were found on the leaves of *A. platanoides* (Table 3). Clearly, eudominant and euconstant *N. aceri* was found more often than other species at both sites; this species represented 92.6% of the total phytoseiid abundance on *A. platanoides* leaves. *E. finlandicus* was recorded on all leaf samples; in total, this species represented 6.6% of the phytoseiid abundance on *A. platanoides* leaves. Both the constancy and dominance of *E. finlandicus* differed between the two studied sites (Table 1). Subrecedent *P. triporus* occurred on the maple leaves at both sites; in total, this species represented only 0.6% of phytoseiid abundance occurring on the leaves of *A. platanoides*.

Table 2. Phytoseiid diversity calculated for different maple species, within each experimental site, using the Margalef index (*d*)

Site	Year	*A. pseudoplatanus*	*A. platanoides*	*A. campestre*
Božtěšice	2013	0.31 ± 0.14	0.16 ± 0.12	0.22 ± 0.15
	2014	0.29 ± 0.10	0.11 ± 0.01	0.27 ± 0.17
Liteň	2013	0.25 ± 0.09	0.23 ± 0.09	0.28 ± 0.11
	2014	0.28 ± 0.10	0.18 ± 0.13	0.25 ± 0.18

values are means ± standard error of the means

Table 3. Mean number of phytoseiid mites on maples

Phytoseiidae	Site	Number of mites per leaf ± SEM		
		A. platanoides	*A. pseudoplatanus*	*A. campestre*
E. finlandicus	B	0.056 ± 0.060[a]	1.280 ± 0.315[b]	0.129 ± 0.077[a]
	L	0.225 ± 0.266[a]	2.173 ± 1.296[b]	0.046 ± 0.064[a]
N. aceri	B	2.149 ± 0.490[a]	0.020 ± 0.024[b]	1.058 ± 0.575[c]
	L	1.693 ± 0.766[a]	0.027 ± 0.030[b]	0.589 ± 0.189[ab]
N. tuberculata	B	0[a]	0.423 ± 0.218[b]	0[a]
	L	0[a]	0.281 ± 0.194[b]	0[a]
T. (T.) pyri	B	0	0.008 ± 0.018	0
	L	0.008 ± 0.024	0.011 ± 0.025	0.073 ± 0.120
P. triporus	B	0.014 ± 0.025	0	0.021 ± 0.025
	L	0.013 ± 0.032[ab]	0[a]	0.038 ± 0.047[b]
P. soleiger	L	0	0	0.002 ± 0.008
Ph. echinus	L	0	0.005 ± 0.016	0

SEM = standard error of the mean, B = Božtěšice, L = Liteň

[a–c]differences among maple species (in rows), Tukey's HSD test (α = 0.05)

Subrecedent and accidental *T. (T.) pyri* was rarely present in the leaf samples; this species accounted for 0.2% of the phytoseiid abundance observed on *A. platanoides* leaves.

Acer pseudoplatanus

A total of 1509 specimens of phytoseiid mites belonging to five species were collected on *A. pseudoplatanus* leaves (Table 3). Eudominant and euconstant *E. finlandicus* was clearly the most abundant species recorded on all observed *A. pseudoplatanus* trees at both sites; this species represented 81.7% of the total abundance observed on *A. pseudoplatanus* leaves. Eudominant *N. tuberculata* was the second most abundant species; in total, this species represented 16.6% of phytoseiids collected from *A. pseudoplatanus* leaves. Different categories of constancy of *N. tuberculata* were recorded at the studied sites (Table 1). *N. tuberculata* was exclusively detected on the leaves of *A. pseudoplatanus*. Recedent and accidental *N. aceri* occurred on the *A. pseudoplatanus* leaves at both sites; this species represented only 1.1% of the total number of phytoseiids sampled from *A. pseudoplatanus*. Subrecedent and accidental *T. (T.) pyri* was sporadically present in the leaf samples collected from *A. pseudoplatanus* at both sites; in total, this species represented 0.5% of the total number of phytoseiids collected on *A. pseudoplatanus* leaves. Only two specimens of subrecedent *Phytoseius echinus* were found on the leaves of *A. pseudoplatanus*.

Acer campestre

Only 688 phytoseiid specimens belonging to five species were found on the leaves of *A. campestre* (Table 3). *N. aceri*, clearly an eudominant and euconstant species, was recorded on all leaf samples of *A. campestre* at both sites; this species represented 84.3% of the phytoseiid abundance observed on the leaves of *A. campestre*. The less abundant *E. finlandicus* accounted for 8.9% of the total abundance of the studied phytoseiid taxocoenosis on *A. campestre* leaves. Both the dominance and the constancy of *E. finlandicus* differed between the two study sites (Table 1). The occurrence of dominant *T. (T.) pyri* on the examined leaves of *A. campestre* was recorded only at one site; this species accounted for 3.6% of the phytoseiid abundance on *A. campestre* leaves. Accidental *P. triporus* was sporadically detected on some leaf samples; in total, this species represented 3.1% of the phytoseiid abundance on *A. campestre* leaves (Table 1). Only one specimen of *P. soleiger* was found on the leaves of *A. campestre* during 2013.

DISCUSSION

The differences in the phytoseiid species number and the phytoseiid species composition were noted among the surveyed maple tree species. The majority of sampled individuals belonged to the species *N. aceri*, which was clearly dominant on the leaves of *A. platanoides* and *A. campestre*. Several species of maples are generally cited as host plants of *N. aceri* (Chant, Yoshida-Shaul, 1989; Tuovinen, Rokx, 1991; Kanouh et al., 2012). Kabíček (2005) recorded the dominant occurrence of *N. aceri* among the phytoseiid species on *A. platanoides* in Bohemia. According to Tuovinen (1993), *N. aceri* was found only on *A. platanoides* in Finland and is specialized with regard to its host plant.

A. campestre appeared to be a favoured host plant for *N. aceri* in Croatia, where it has also frequently been sampled from *A. pseudoplatanus* (Tixier et al., 2010). Interestingly, the surveyed leaves of *A. pseudoplatanus* were infrequently inhabited by *N. aceri*, which may indicate a lower degree of association with this tree species. *N. aceri* was also reported on many broadleaved trees (*Aesculus hippocastanum*, *Alnus incana*, *Carpinus betulus*, *Corylus avellana*, *Juglans regia, Morus alba*, *Prunus* spp., *Quercus ilex*, *Rubus* sp.) and certain coniferous (*Juniperus sabina*, *Pinus sylvestris,* and *Picea* sp.) trees and shrubs (Chant, Yoshida-Shaul,1989; Karg, 1993; Kabíček, 2010; Tixier et al., 2010; Kanouh et al., 2012). The frequent and common occurrence of *N. aceri* on *A. platanoides* and *A. campestre* might indicate the suitability of these maple species as host plants for this mite. Similarly, repeated findings of *N. tuberculata* only on *A. pseudoplatanus* may indicate its suitability as a host plant for this phytoseiid mite species. *N. tuberculata* has been observed on several other deciduous (*A. pseudoplatanus*, *Acer* spp., *Ae. hippocastanum*, *J. regia*, and *Ribes uva-crispa*) trees and shrubs (Chant, Yoshida-Shaul,1989; Tixier et al., 2010) and has recently been observed on *A. platanoides* in France (Kanouh et al., 2012).

The occurrence of the other more abundant phytoseiid species, *E. finlandicus*, differed among the examined maple species. *E. finlandicus* was only an eudominant and euconstant phytoseiid species on *A. pseudoplatanus*, whereas it was less abundant on *A. platanoides* and *A. campestre*. *E. finlandicus*, a pollen feeder and a predator of eriophyoid and tetranychid mites (Broufas, Koveos, 2000; Awad et al., 2001; McMurtry et al., 2013), was collected from *Armeniaca vulgaris*, *Ae. hippocastanum*, *Betula* sp., *Fragaria* sp., *Castanea sativa*, *Carpinus* sp., *C. avellana*, *Syringa* sp., *Prunus cerasus*, *Pyrus* sp., *Malus* spp., *Vitis* sp., and many other plants (Kolodochka, 1978; Hluchý et al., 1991; Ragusa, Ragusa, 1997; Papaioannou-Souliotis et al., 2000; Stojnić et al., 2014). According to Duso et al. (2004), *E. finlandicus* is dominant on natural vegetation, and some of its characteristics (a high dispersal ability, a wide range of alternative food, no restrictions to a certain type of habitat, and a great tendency to interspecific predation, among others) may influence and explain its common occurrence on deciduous trees and bushes (Schausberger, 1997). In the present study, both *A. platanoides* and *A. campestre* trees seem to be less favourable host plants for *E. finlandicus*.

Less abundant *Typhlodromus (Typhlodromus) pyri* was found only on several surveyed maple trees. *T. (T.) pyri* was observed on *Acer* spp., *Ae. hippocastanum*, *C. avellana*, *Quercus* sp., *Syringa vulgaris*, *Tilia platyphyllos*, *Viburnum* sp., some other deciduous trees and many other plants (Chant, Yoshida-Shaul, 1987; Miedema, 1987; Edland, Evans, 1998; Papaioannou-Souliotis et al., 2000; Duso et al., 2004). This phytoseiid species is one of several predators that occur naturally on grapevines and apple trees planted in commercial chemically treated orchards and vineyards (Hluchý et al., 1991; Kreiter et al., 2000; Papaioannou-Souliotis et al., 2000; Fitzgerald, Solomon, 2002; Tixier et al., 2013). *T. (T.) pyri* is able to survive in agroecosystems through its specific potential to develop some resistance to pesticides. As an efficient predator, *T. (T.) pyri* is used as biological control agent to suppress populations of tetranychids and other phytophagous mites (Van de Vrie, 1985; Duso, Camporese, 1991; Zacharda, 1991; Gerson et al., 2003). A relatively sporadic occurrence of *T. (T.) pyri* specimens on the observed *Acer* species might indicate that *Acer* species are less suitable host plants for them.

The differences in the occurrence of the dominant phytoseiids were recorded among the maple species. The abundance and frequent occurrence of the phytoseiids recorded on the examined maple tree species indicate that these deciduous trees may constitute natural reservoirs and suitable host plants for some native phytoseiid species.

CONCLUSION

Phytoseiid species composition differed among the surveyed maple tree species, which may serve as suitable host plants for certain phytoseiid species. Among them, the most common phytoseiid species was *N. aceri*, whose biology is not well known. Woody plants inhabited by specific phytoseiid species could be used in a targeted manner within the conservation strategy as natural reservoirs of native phytoseiids. A better knowledge of the occurrence of phytoseiid communities on natural vegetation is needed because it might contribute to an increase in the number of phytoseiid species useable for conservation biological control.

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