



Predatory Mites and Spider Mites (Acari: Phytoseiidae and Tetranychidae) on Oak Trees in Serbia

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Abstract: This study aimed to examine the diversity of leaf-inhabiting mites in oak trees of deciduous forests (natural and plantations) and urban areas (parks, forest parks, roadside greeneries and gardens) in Serbia. The survey was carried out in April – October between 2010 and 2018. The results refer to seven oak species, six of them native to Europe and one introduced from North America. Twelve mite species were recorded, nine of the family Phytoseiidae Berlese, 1916 and three of the family Tetranychidae Donnadieu, 1875. There were three predatory mite species new to the acarofauna of Serbia, i.e. *Typhloseiulus peculiaris* (Kolodochka, 1980), *T. simplex* (Chant, 1956) and *Typhlodromus (Anthoseius) intercalaris* Livshitz & Kuznetsov, 1972. The only spider mite species new to the acarofauna of Serbia was *Oligonychus endytus* Pritchard and Baker, 1955. This was also the first record of *O. endytus* in the Palearctic Region. The most common phytoseiid species found from oak species in Serbia were *Euseius finlandicus* (Oudemans, 1915), *Kampimodromus aberrans* (Oudemans, 1930) and *T. (A.) rhenanus* (Oudemans, 1905), while the frequent tetranychid species included *O. brevipodus* (Targioni Tozzetti, 1878) and *Schizotetranychus garmani* Pritchard & Baker, 1955.

Key words: Species diversity, spider mites, predatory mites, *Quercus* sp.

Introduction

Approximately 430 deciduous and evergreen tree and shrub species of the genus *Quercus* L. are known from the Northern Hemisphere. Seven of them, which are native to the Serbian flora, mostly occur in Southern and South-Eastern Europe and Western Asia (CVJETIĆANIN et al. 2016). Oaks are among the most important forest species in Serbia and account for about 25% of the total forest stands (BANKOVIĆ et al. 2009). *Quercus rubra* L. originates from the eastern and central United States and southeastern and south-central Canada; it has been

introduced to Europe during the 18th and 19th centuries (VUKIĆEVIĆ 1996).

Substantial damage caused by spider mites has often occurred in agriculture and horticulture since the middle of the 20th century. This damage has often been inflicted by extensive environmental changes caused by human activity (PETANOVIĆ et al. 2010). Among numerous phytophagous mites and insects, phytoseiids generally prey upon the family Tetranychidae. On that account, they have been thoroughly studied in the context of biological control and integrated pest management programmes (GERSON et al. 2003, HOY 2011, McMURTRY et al.

2013). Various wild trees can serve as host plants and winter refuges for phytoseiids. The sites that abound in non-cultivated plant species represent a natural reservoir of predatory mites (TIXIER et al. 2000a, 2000b); the same is valid for various alien plant species that commonly occur in urban areas (SHAPIRO 2002). Non-native oak species can sometimes be suitable plant hosts to certain phytoseiid species, especially in environmentally unfriendly urban areas (KABICEK 2017).

This paper presents results of species diversity, distribution and faunistic analysis of the complexes of spider mites and their phytoseiid predators on oak species in Serbia.

Materials and Methods

Leaf samples were collected in deciduous forests (natural and plantations) and urban areas (parks, forest parks, roadside greenery and gardens) in Serbia at 65 sampling locations during the growing (most often from April to October) in the period between 2010 and 2018. The studied locations were grouped into 18 areas for simplification (Fig. 1). Leaf samples were collected from seven oak species, six of which are autochthonous: *Q. cerris* L., *Q. frainetto* Ten., *Q. petraea* (Matt.) Liebl., *Q. pubescens* Willd., *Q. robur* L. and *Q. trojana* Webb., while one species (*Q. rubra* L.) was introduced to Europe from North America.

Totally, 78 samples were collected. Each sample consisted of a hundred leaves. The leaves were sampled from all sides of the tree crown at shoulder height. Each sample was carefully examined using a stereomicroscope (Leica Wild M3Z) to separate the mites. The mites were fixed according to standard methodology after which they were mounted in Hoyer's medium (EVANS & BROWING 1955, KRANTZ & WALTER 2009) on slides for further examination and species identification using a phase-contrast light microscope (Leica DMLS). We followed the nomenclature of DEMITE et al. (2020) for the phytoseiid species of MIGEON & DORKELD (2020) for the tetranychid species. The species were identified using the keys and relevant books and papers for the family Phytoseiidae (CHANT 1959, KARG 1993, CHANT & McMURTRY 2007, TIXIER et al. 2012) and the family Tetranychidae (PRITCHARD & BAKER 1955, RECK 1959, BAKER & PRITCHARD 1960, LIVSHITS & MITROFANOV 1971, JEPSON et al. 1975, BAKER & TUTTLE 1994, BOLLAND et al. 1998, FLECHTMANN 2012).

The constancy of occurrence C (DAJOZ 1977) was used to determine the ratio between the number of samples in which a given species occurred and the number of all samples. Based on their index values

(TISCHLER 1965), the species were classified as accidental ($C \leq 25\%$), accessory ($C = 25.1-50\%$), constant ($C = 50.1-75\%$) or euconstant ($C = 75.1-100\%$), with the index values $C > 50\%$ indicating a strong relationship between the species and the studied habitat.

Voucher specimens were deposited at the Department of Forest Protection, Institute of Forestry, Belgrade, and the Department of Entomology and Agricultural Zoology, Faculty of Agriculture, University of Belgrade.

Results

Seven oak species were found to host a species complex of twelve leaf-inhabiting mite species (Table 1). Totally, nine phytoseiid species of six genera of the two subfamilies were found. Three spider mite species of two genera of one subfamily were also detected. For the species localities, see Fig. 2.

The largest species complex of leaf-inhabiting mites was recorded in *Q. cerris* (11 species), followed by *Q. petraea* (7 species), *Q. frainetto* and *Q. robur* (6 species each). For the remaining oak species, *Q. rubra* (2 species), *Q. pubescens* and *Q. trojana*, we recorded only one species on each (Table 1). Only one species from the complex of oak leaf-inhabiting mites was constant, while the remaining 11 species belonged to the group of accidental species (Table 1).

Three predatory mite species were recorded as new in the acarofauna of Serbia: *T. peculiaris*, *T. simplex* and *T. (A.) intercalaris*. The spider mite species *O. endytus* was recorded for the first time in the fauna of Serbia and the Palaearctic, as well as outside of the Nearctic Region.

New data on host plant species were also obtained: four tree species for predatory mite species and two tree species for spider mite species (Table 3).

Of the total number of samples, phytoseiid mites were found in 82% and tetranychid mites were recorded in 45%. The complex of phytoseiid and tetranychid species was determined in 27% of the samples. Most samples (73%) were inhabited only by one phytoseiid species.

The largest number of samples contained only one predatory species, while much smaller number of samples contained several phytoseiid species in cohabitation (Table 4).

Discussion

Worldwide, there are 54 species of the family Phytoseiidae (DEMITE et al. 2020) and 68 species of the family Tetranychidae recorded on the genus *Quercus* (MIGEON & DORKELD 2020). Previous studies of oak

Table 1. Predatory mites (Phytoseiidae) and spider mites (Tetranychidae) collected on *Quercus* spp. in Serbia: distribution and constancy of species

Mite species	Host species							C %
	<i>Quercus cerris</i>	<i>Quercus frainetto</i>	<i>Quercus petraea</i>	<i>Quercus robur</i>	<i>Quercus pubescens</i>	<i>Quercus rubra</i>	<i>Quercus trojana</i>	
<i>Family Phytoseiidae</i>								
Subfamily Amblyseiinae								
<i>Amblyseius andersoni</i>	*	*		*				5.1
<i>Euseius finlandicus</i>	*	*	*	*	*	*	*	62.8
<i>Kampimodromus aberrans</i>	*	*	*	*				15.4
Subfamily Typhlodrominae								
<i>Neoseiulella aceri</i>		*						1.3
<i>Typhlodromus (A.) bakeri</i>	*							1.3
<i>Typhlodromus (A.) intercalaris</i>	*	*				*		5.1
<i>Typhlodromus (A.) rhenanus</i>	*	*	*	*				11.5
<i>Typhloseiulus peculiaris</i>	*		*					2.6
<i>Typhloseiulus simplex</i>	*							2.6
Family Tetranychidae								
Subfamily Tetranychinae								
<i>Oligonychus brevipodus</i>	*		*	*				21.8
<i>Oligonychus endytus</i>	*		*					9.0
<i>Schizotetranychus garmani</i>	*		*	*				21.8

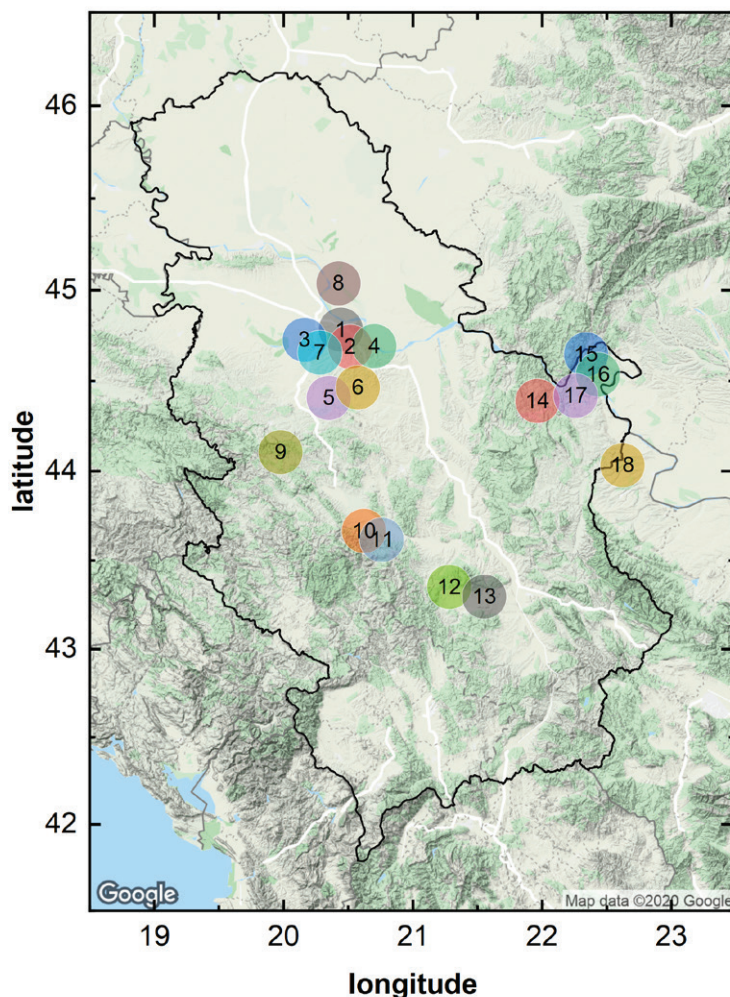

Fig 1. Investigated areas in Serbia (the numbers in parentheses indicate the quantity of the sampling locations in each area). 1 – Belgrade (23); 2 – Avala (6); 3 – Progar, Bojčin (3); 4 – Grocka (1); 5 – Lazarevac (2); 6 – Kosmaj (1); 7 – Obrenovac (2); 8 – Opovo (2); 9 – Maljen, Divčibare (3); 10 – Stolovi (2); 11 – Goč (4); 12 – Veliki Jastrebac (2); 13 – Mali Jastrebac (2); 14 – Majdanpek (5); 15 – Miroč (1); 16 – Grabovica, Alija (2); 17 – Štubik, Jabukovac, Vratna (3); 18 – Negotin (1).

Table 2. Collection sites of the specimens examined

Plant species	Sampling localities and dates
<i>Q. petraea</i>	Maljen, Divčibare: 44°06'18"N, 19°59'21"E, 06.06.2011
<i>Q. cerris</i>	Maljen, Divčibare: 44°06'14"N, 19°59'12"E, 06.06.2011 44°06'34"N, 19°59'55"E, 06.06.2011
	Veliki Jastrebac, Prokupac: 43°20'04"N, 21°28'55"E, 26.06.2011
	Mali Jastrebac, Dobrić: 43°20'04"N, 21°28'55"E, 26.06.2011
	Obrenovac, Moštanica: 44°39'11"N, 20°70'45"E, 13.08.2015
	44°41'21"N, 20°21'39"E, 13.08.2015

Table 3. New host plants for Phytoseiidae and Tetranychidae

Mites species	New host genus	New host species
<i>T. (A.) intercalaris</i>	/	<i>Q. cerris</i> , <i>Q. frainetto</i> , <i>Q. rubra</i>
<i>T. peculiaris</i>	<i>Quercus</i>	<i>Q. cerris</i> , <i>Q. petraea</i>
<i>T. simplex</i>	<i>Quercus</i>	<i>Q. cerris</i>
<i>O. brevipodus</i>	/	<i>Q. petraea</i>
<i>O. endytus</i>	/	<i>Q. cerris</i> , <i>Q. petraea</i>
<i>S. garmani</i>	/	<i>Q. cerris</i> , <i>Q. petraea</i>

Table 4. Cohabitation of phytoseiid mites on the leaves of *Quercus* spp.

Number of species/ sample	Sample (%)
0	0.0
1	73.0
2	22.0
3	3.0
4	2.0

trees in Serbia recorded the presence of two phytoseiid species and eight spider mite species on five autochthonous oaks (STOJNIĆ 1993, MLADENOVIĆ et al. 2011, 2012, MARIĆ et al. 2018b, 2020).

The only constant species (*E. finlandicus*) is a generalist predator from the IV group whose diet is based on pollen and optionally on mites, mainly eriophyes and tetranychides (BROUFAS & KOVEOS 2000, McMURTRY et al. 2013). It prefers smooth to moderately hairy leaves (KABICEK 2005, 2008) and can bite plant cells to absorb water and nutrients (CHANT 1959). It is the most commonly occurring phytoseiid species in Serbia, already found in 120 plant species from 77 genera (STOJNIĆ & MLADENOVIĆ 2017). Since it is predominantly an

arboreal species, its presence has the greatest impact on the species and functional composition of the existing phytoseiid complexes on woody plants in Serbia (STOJNIĆ & MLADENOVIĆ 2017). *Euseius finlandicus* is a cosmopolite and one of the most commonly found phytoseiid species on a great number of plant species, both woody and herbaceous (DEMITE et al. 2020). KARG (1992) considers that this taxon is the prevailing species on fruit trees and other woody plants in Europe. KABICEK & POVONDROVA (2004) state that *E. finlandicus* is the dominant phytoseiid species on the studied trees in the urban forests with low host plant specificity. *Kampimodromus aberrans* and *T. (A.) rhenanus* are more common than other accidental phytoseiid species on oaks in Serbia. *Kampimodromus aberrans* belongs to the generalist predators from the IIIa group that have a wide range of potential prey and prefers hairy leaves (KREITER et al. 2002, KABICEK 2008, DUSO et al. 2009, McMURTRY et al. 2013). It has a Holarctic distribution (DEMITE et al. 2020) and is ranked fourth among the phytoseiid species based on its frequency of occurring on the plants in Serbia (STOJNIĆ & MLADENOVIĆ 2017). *Typhlodromus (A.) rhenanus* is a generalist predator from the IIIb group; it has a wide trophic spectrum and prefers smooth leaves (CHANT 1959, McMURTRY et al. 2013). This species is distributed in the Holarctic, Neotropic and Oriental regions (DEMITE et al. 2020). It is the second most frequent phytoseiid species on the plants in Serbia (STOJNIĆ & MLADENOVIĆ 2017). *Amblyseius andersoni* Chant, 1957 is a generalist predator from the IIIb group, which inhabits glabrous leaves (CAMPORSE & DUSO 1995, DUSO et al. 2003, McMURTRY et al. 2013). It is a Holarctic species (DEMITE et al. 2020) and the third most frequent species on plants in Serbia (STOJNIĆ & MLADENOVIĆ 2017). *Typhlodromus (Anthoseius) bakeri* Garman, 1948 is a selective predator of tetranychid mites with plant-cell piercing abilities (McMURTRY et al. 2013) and *Neoseiulella aceri* Collyer, 1957 is a generalist predatory species that prefers sheltered leaf microhabitats (KABICEK 2019). Both are low-frequency species in Serbia. *Typhlodromus (A.) bakeri* is distributed in the Holarctic, Oriental and Australasian regions. On the other hand, *N. aceri* has been recorded only in the Holarctic ecozone (DEMITE et al. 2020).

Schizotetranychus garmani has been found in Serbia on *Q. robur* (STOJNIĆ 1993, MARIĆ et al. 2018b) and the woody plant species of the genera *Acer*, *Aesculus*, *Corylus*, *Fagus*, *Fraxinus*, *Salix*, *Ulmus* and *Quercus* (see STOJNIĆ 1993, MLADENOVIĆ et al. 2013a, MLADENOVIĆ 2014). It

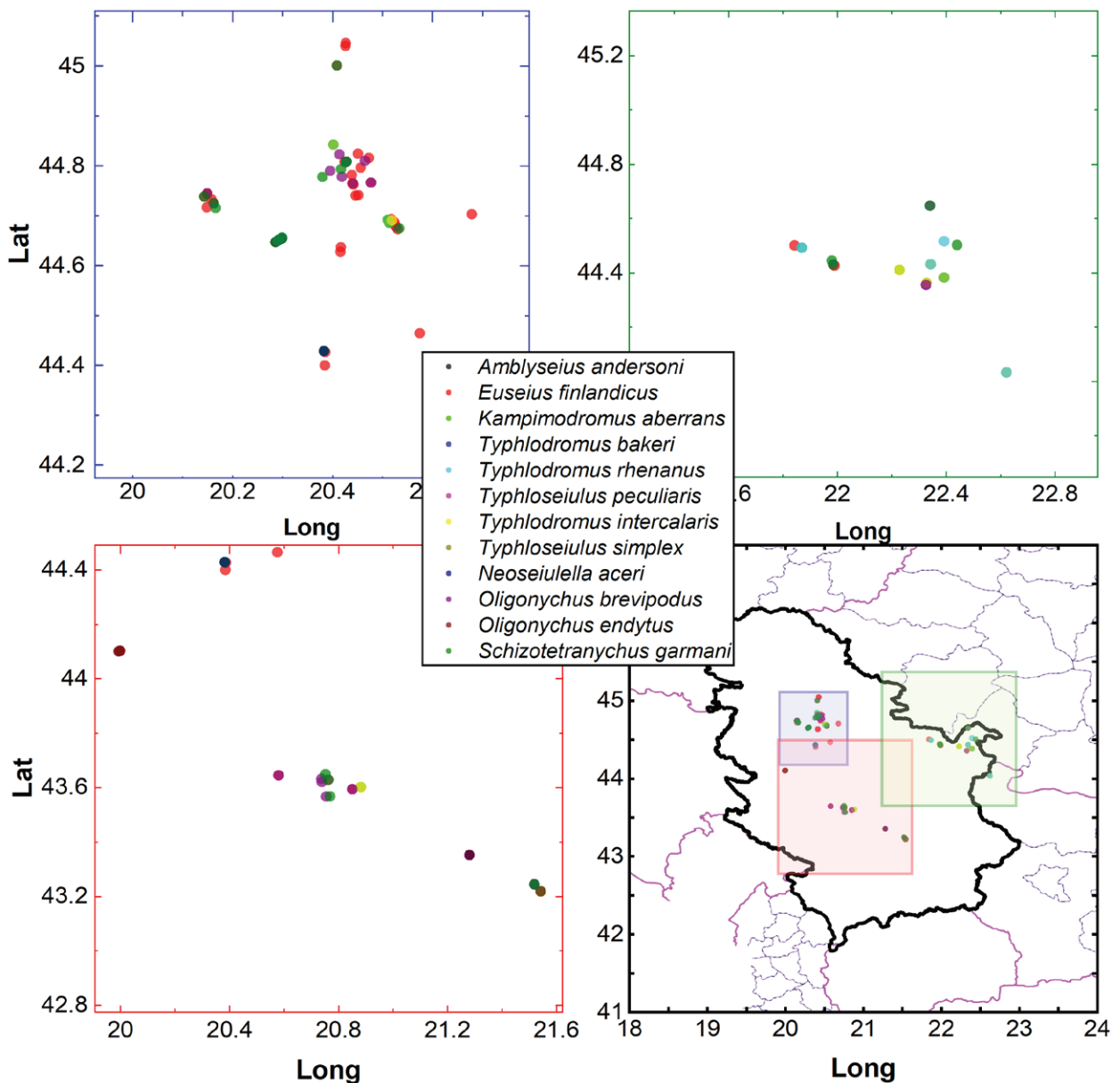


Fig 2. Locations where Tetranychidae and Phytoseiidae have been recorded on *Quercus* spp. in Serbia.

has a Holarctic distribution (MIGEON & DORKELD 2020). In Serbia, *O. brevipodus* has been recorded on *Q. cerris* and *Q. robur* (STOJNIĆ 1993, MARIĆ et al. 2018b). According to the available data, it is most probably a monophagous species feeding on oaks. It has been found in the Palaearctic and in the Australasian zone (KONTSCHAN & RIPKA 2017, MIGEON & DORKELD 2020). The geographical distribution of *O. endytus*, before the present report, appeared to be exclusively in the Nearctic; this mite species has been found in states distant from each other (in the United States) on different host plants. This species has been recorded on oaks (*Q. lobata*, *Quercus* spp.) and chestnut (*Castanea dentata*) in California (PRITCHARD & BAKER 1955,

BAKER & TUTTLE 1994) while, in Georgia, it occurs on *Elaeagnus* sp. and *Ilex* sp. (FLECHTMANN & HUNTER 1971) and, in Michigan, on *Acer* sp. and *Cornus* sp. (PRASAD 1970). In California, *O. endytus* is known as a serious pest of chestnut while the oak infestation can be described as moderate (PRITCHARD & BAKER 1955, JEPSON et al. 1975, BAKER & TUTTLE 1994). The mite feeds mostly along the leaf veins and causes mild discoloration. Webbing is moderately present.

The first records of *T. (A.) intercalaris*, *T. peculiaris* and *T. simplex* in Serbia supplement the data on their known Palaearctic distribution (DEMITE et al. 2020). Since there are no other records of *O. endytus* in the Palaearctic, we recognise it as an allochtho-

nous species, probably introduced with seedlings of *Q. rubra*. This oak species has been introduced to Serbia due to its fast growing and lower requirements to soil condition than the autochthonous sessile oak and pedunculate oak. Red oak is grown in Serbia in artificially planted stands on 25,432 ha (ANONYMOUS 2019); however, it is also frequent as a decorative tree. In Serbia, *O. endytus* has been recorded on *Q. cerris* and *Q. petraea* in several localities (Table 2). It has been found at localities close to artificially-planted stands of red oak (Mt. Mali Jastrebac, Mt. Veliki Jastrebac, Moštanica) but also in urbanised and semi-urbanised areas (Divčibare Plateau on Mt. Maljen).

We present new host records for the following predatory mites and spider mites: *T. (A.) intercalaris* on *Q. cerris*, *Q. frainetto* and *Q. rubra*; *T. peculiaris* on *Q. cerris* and *Q. petraea*; *T. simplex* on *Q. cerris*. New host plants are *Q. cerris* and *Q. petraea* for both *O. endytus* and *S. garmani* as well as *Q. petraea* for *O. brevipodus* (Table 3).

Competition and predation among phytoseiids have significant impact on biology and survival of these mites (ZHANG & CROFT 1995, SLONE & CROFT 2000). The co-habitation of two phytoseiid species was found in 22 % of the samples. The co-habitation of three and four species was found in 3% and 2% of the samples. The co-habitation of more than four phytoseiid species per sample was not observed.

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