Cohabitation and Intraleaf Distribution of Phytoseiid Mites (Acari: Phytoseiidae) on Leaves of *Corylus avellana*

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Abstract

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Leaves from uncultivated and unsprayed hazelnut shrubs, *Corylus avellana,* were sampled from June to August 2005 to obtain information on the phytoseiid mite taxocenoses, population density and intraleaf distribution. Six phytoseiid mite species were identified, of which three, *Kampimodromus aberrans*, *Euseius finlandicus* and *Neoseiulella tiliarum*, were more abundant. The eudominant, slowly moving *K. aberrans* was found on all leaf samples. Phytoseiid population density averaged 3.16 mites per hazelnut leaf. While on most leaves only one phytoseiid species was found, on some there was cohabitation of two (rarely three) species. The three frequent species mostly inhabited the sheltered microhabitat at the veins of leaves of *C. avellana.*

Keywords: *Kampimodromus aberrans*; leaf microhabitat; phytoseiid location; shelter; behavior; defensive strategy; hazelnut; fauna

The majority of phytoseiid mite species are known as natural enemies of small arthropods. In natural habitats, some phytoseiids play an important role in preventing outbreaks of various phytophagous mites (Edland & Evans 1998). Some phytoseiid species are used as effective biological control agents of diverse agriculturally important pests in many crops (McMurtry *et al.* 1970; Helle & Sabelis 1985; Gerson *et al.* 2003). Many phytoseiid species often live on leaves of various deciduous tree and shrub species. Pubescence, raised veins, domatia and other structures on the leaf undersurfaces may positively influence the occurrence of some phytoseiid species (Walter 1992; Kreiter *et al.* 2002; Duso *et al.* 2003; Seelmann *et al.* 2007).

Unsprayed trees and shrubs serve as reservoirs for phytoseiids from where they can migrate into nearby coenoses (Tuovinen & Rokx 1991; Strong & Croft 1993). The phytoseiid mite taxocenoses and role of the common phytoseiid species *Kampimodromus aberrans* in the control of important eriophyid mite pests on hazelnuts cultivated in Mediterranean countries with a favourable climate are well-known (Tsolakis *et al.* 2000; Ozman-Sullivan 2006). While in many regions of Bohemia cultivated or mostly uncultivated hazelnuts are common, the knowledge of the phytoseiid mites on them is scarce.

The aims of this preliminary study were to investigate the occurrence, species diversity and abundance of phytoseiids on leaves of hazelnut shrubs. The

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intraleaf distribution of the most frequent phytoseiid species on hazelnut leaves was also reported.

MATERIAL AND METHODS

Leaves from seven unsprayed and uncultivated shrubs of *Corylus avellana* L. at one site near Božtěšice (50°42'N, 14°01'E), North Bohemia, were sampled five times between 5 June to 30 August in 2005. On the sampling dates, the standard sample size per shrub was ten randomly selected leaves of approximately identical size and age; in total, 350 leaves were collected. Each single collected leaf was immediately placed in a plastic bag and stored in a cold-storage box until examination in the laboratory. Cooled leaves were inspected individually using a binocular microscope with fibre-optic illumination. Various structures, i.e. tuft domatia at vein junctions, numerous cavities widespread mainly along the raised mid-ribs that are densely covered with long hair trichomes, slightly (in comparison with veins) pubescent leaf blade, were recorded on leaf undersurfaces. The entire leaf surface was scanned. For reporting the positions where mites were found, the underside of each leaf was divided into three microhabitats: vein, domatia and leaf blade. Mites found near veins (domatia) within a distance of the two-fold body length of the mite were included in the vein (domatia) microhabitat. The accurate positions and numbers of active stages of phytoseiid mites per each leaf microhabitat were recorded. Mite densities were expressed as the number of motile stages per leaf. Phytoseiids were separated from leaves by using insect pins and mounted in Swann medium on microscope slides; they were determined using the keys of Beglyarov (1981a, b) and Ragusa di Chiara and Tsolakis (1994).

Table 1. Phytoseiid species per hazelnut leaf

Number of species/leaf	Leaves+ (%)
0	13.1
1	66.3
2	20.0
3	0.6
4	0.0

+All samples leaves

RESULTS AND DISCUSSION

All sampled hazelnut shrubs were inhabited by phytoseiid mites. The six species were *Kampimodromus aberrans* (Oudemans, 1930), *Euseius finlandicus* (Oudemans, 1915), *Neoseiulella tiliarum* (Oudemans, 1930), *Neoseiulella aceri* (Collyer, 1957), *Typhlodromus pyri* (Scheuten, 1857) and *Galendromus longipilus* (Nesbitt, 1951). A total of 1105 specimens were found on the undersurfaces of inspected leaves, but none were recorded on the adaxial leaf area. Thirteen phytoseiid species had been reported from hazelnut orchards in Turkey by Ozman-Sullivan (2006). Tsolakis *et al.* (2000), who had for 3 years screened hazelnut shrubs with limited cultural practices at two sites in Sicily, had found 19 species of phytoseiids from which only four species were more abundant.

Mites of the family Phytoseiidae occurred on almost 87% of all sampled leaves. The presence/absence of phytoseiid species on sampled leaves of *C. avellana* are listed in Table 1. Most leaves (76.3% of all leaves with phytoseiids) were inhabited by only one mite species. Two species per leaf were found on almost 23% of the leaves with phytoseiids. The simultaneous occurrence of

Table 2. Co-occurrence of phytoseiid species on leaves of *Corylus avellana*

Phytoseiid species	Leaves+ (%)					
	K. aberrans	*E. finlandicus*	*N. tiliarum*	*N. aceri*	*G. longipilus*	*T. pyri*
K. aberrans	61.5					
E. finlandicus	5.9	9.2				
N. tiliarum	13.8	1.3	5.6			
N. aceri	0.3	0.0	0.0	0.0		
G. longipilus	0.7	0.3	0.0	0.0	0.0	
T. pyri	0.3	0.0	0.3	0.0	0.0	0.0

+Leaves with phytoseiids only

K. aberrans with *N. tiliarum* on a leaf was more frequent than co-occurrence of *K. aberrans* with *E. finlandicus* (Table 2). Various studies have shown that competition and predation among phytoseiids play an important role in biology and survival of phytoseiid mites on leaves (Zhang & Croft 1995; Schausberger 1997; Slone & Croft 2000). According to Seelman *et al.* (2007), leaf pubescence negatively affects survival chances of *E. finlandicus* on leaves in the presence of the intraguild predator *K. aberrans*. Co-occurrence on a leaf of two of the other phytoseiid species was sporadic because of their lower population density. Three species on one leaf were recorded only on two hazelnut leaves (0.7% of all leaves with phytoseiids). Cohabitation by more than three phytoseiid species per leaf was not observed.

The population density of phytoseiids averaged 3.16 mites per hazelnut leaf. Three phytoseiids (*K. aberrans, E. finlandicus* and *N. tiliarum*) were the more frequent species on inspected leaves (total of 1098 specimens). The eudominant species

Table 3. Population density of phytoseiid mites on leaves of *Corylus avellana*

Phytoseiid species	Mites per leaf
Kampimodromus aberrans	2.514
Euseius finlandicus	0.380
Neoseiuella tiliarum	0.243
Galendromus longipilus	0.011
Typhlodromus pyri	0.006
Neoseiuella aceri	0.003

K. aberrans was found on more than 83% of all leaves with phytoseiids and it was recorded in all samples. The abundance of this species peaked at 2.5 mites per leaf (Table 3). It has the known tendency to inhabit leaves with high pubescence (Camporese & Duso 1996; Kreiter *et al.* 2002). Hazelnut leaves with hairy trichomes on the abaxial area are predetermined for frequent occurrence of *K. aberrans*. According to Seelmann *et al.* (2007), immature *K. aberrans* are more likely to survive on pubescent leaves than on glabrous ones. Many hairs on leaves confer a competitive advantage to *K. aberrans* over other phytoseiid mite species (Kreiter *et al.* 2002). The other phytoseiid species were not recorded in all samples (Table 5). Three of them, *G. longipilus, T. pyri* and *N. aceri,* were found at low densities on leaf undersurfaces of *C. avellana*. The population densities of all collected mite species are presented in Table 3.

Most specimens of *K. aberrans* were found near the main prominent raised veins with long trichomes and within non-distinct domatia created by tufts of hairs in the vein axils on the underside of leaves. The colonisation of the leaf vein microhabitat by motile stages of *K. aberrans* was higher (more than 62% of individuals) (Table 4). Leaf surface structures are significant determinants of the abundance and microhabitat preference of phytoseiid mites that inhabit leaves (Walter & O'Dowd 1992; Karban *et al.* 1995; Kabíček 2003). *Kampimodromus aberrans* persisted in the sheltered vein and domatia microhabitats during inspection of the leaves, and many specimens changed their position on leaves reluctantly and moved relatively slowly when disturbed. Such be-

Table 4. Location of phytoseiid motile stages in leaf microhabitats

Phytoseiid species	Leaf microhabitat	Active mite stage (%)			Total (%)
		immatures	females	males	
	leaf blade	14.0	6.0	13.7	9.8
Kampimodromus aberrans	veins	59.2	64.8	59.9	62.3
	domatia	26.8	29.2	26.4	27.9
	leaf blade	15.0	10.1	28.6	12.8
Euseius finlandicus	veins	55.0	46.5	71.4	50.3
	domatia	30.0	43.4	0.0	36.9
	leaf blade	12.5	3.5	18.2	7.1
Neoseiuella tiliarum	veins	50.0	67.2	72.7	64.7
	domatia	37.5	29.3	9.1	28.2

haviour was also observed in other slowly moving phytoseiid mites – *N. aceri* on maple leaves with well-developed tuft domatia and *Phytoseius juvenis* Wainstein *et* Arutunyan on densely pubescent leaves of *Salix caprea* (Kabíček 2005). This may be related with the type of defensive strategy to avoid predators.

Both immature active stages and adults of *E. finlandicus* were mostly recorded within the sheltered vein and domatia microhabitats, though its males were not found in the domatia microhabitat (Table 4). All mobile stages (more than 50% of individuals) preferred the leaf vein microhabitat. Specimens of *E. finlandicus* rapidly changed their position on leaves when disturbed. In comparison with *N. tiliarum* and *K. aberrans*, individuals of *E. finlandicus* were frequently detected in the less pubescent leaf blade microhabitat (Table 4). Phytoseiid body size and setae influence the ability of movement through leaf hairs (Walter 1992; Kreiter *et al.* 2002). As a large phytoseiid mite (Schausberger 1992), *E. finlandicus* easily and rapidly moves on a glabrous leaf area (Tuovinen 1994; Kabíček 2005) that allows them to effectively utilize their defensive strategy that depends on rapid escape before predators.

Both motile immatures and females of *N. tiliarum* preferred the sheltered vein and domatia microhabitats while males were more frequently captured in the vein and leaf blade microhabitats (Table 4). The most preferred microhabitat by active stages of *N. tiliarum* were numerous cavities that are spread mainly along the raised mid-ribs; almost 65% of the individuals were found there. According to Kreiter *et al.* (2002), *N. tiliarum* is a small phytoseiid mite that prefers hairy domatia on glabrous leaves.

The results obtained by this study show that *K. aberrans* was the eudominant slowly moving phytoseiid species on hazelnut leaves. The three frequent phytoseiid species mostly inhabited the sheltered leaf vein microhabitat on the leaves. Though cohabitation of phytoseiid species on hazelnut leaves was observed in the field, on most leaves only one of the species was found.

Table 5. Frequency of phytoseiid species occurrence per leaf samples (100% = 35 samples)

Phytoseiid species	Samples (%)
Kampimodromus aberrans	100.0
Euseius finlandicus	48.6
Neoseiuella tiliarum	74.3
Galendromus longipilus	8.6
Typhlodromus pyri	2.6
Neoseiuella aceri	2.6

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