# DIVERSITY AND ABUNDANCE OF PHYTOSEIID MITES (ACARI: PHYTOSEIIDAE) IN VINEYARDS AND THE SURROUNDING VEGETATION IN NORTHEASTERN ITALY

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*(Accepté September 2003)*

RÉSUMÉ: Des échantillonnages sur les acariens ont été réalisés dans des milieux non cultivés autour de six vignobles, et dans ces vignobles, dans diffèrents environnements viticoles de l'Italie du nord pendant trois ans. Les acariens phytophages (en particulier Tetranychoidea et Eriophyoidea) ont été observés rarement tandis que les tydéides (Tydeoidea) étaient abondants soit dans les vignobles soit dans les milieux non cultivés. D'autres acariens (Winterschmidtiidae) ont été rencontrés seulement sur les plantes spontanées. Les phytoséiides (Phytoseiidae) ont été rencontrées fréquemment dans les vignobles et dans les milieux non cultivés. Six espèces de phytoséiides ont été recensées dans les vignobles et 18 espèces dans la végétation spontanée. Les caractéristiques foliaires semblent avoir une influence importante sur la colonisation des phytoséiides. Dans certains environnements des espèces comme *Amblyseius andersoni* et *Typhlodromus pyri* étaient abondantes soit dans les vignobles soit dans les milieux non cultivés. Certaines plantes spontanées présentaient des densités relativement élevées de phytoséiides ou étaient colonisées par plusieurs espèces. Elles peuvent être considérées dans les projets concernant l'aménagement dirigé des bordures des vignobles en particulier des haies.

ACARI
PHYTOSEIIDAE
BIODIVERSITY
GRAPEVINE
NATURAL VEGETATION
BIOLOGICAL CONTROL

SUMMARY: Surveys of mites occurring in six vineyards and in the surrounding vegetation (hedgerows and stand margins) were carried out in different areas of the Veneto Region (north-eastern Italy). Phytophagous mites (e.g. Tetranychoidea and Eriophyoidea) were rarely abundant in vineyards and the surrounding vegetation. Tydeoidea were widespread in vineyards and on wild plants, Winterschmidtiidae common on some wild plants but not in vineyards. Phytoseiidae were a major part of the mite communities in vineyards and on natural vegetation. A total of 18 phytoseiid species were found on the natural vegetation, 6 species occurring on grapevines. Leaf morphology appeared to be more important than prey availability with regard to phytoseiid colonization.

Some predatory species dominated in both the vineyard and the natural vegetation, in particular *Amblyseius andersoni* and *Typhlodromus pyri*. The mechanisms affecting abundance and persistence of phytoseiids on wild plants should be studied to optimise strategies for successful population management in vineyards. Plant species with rich phytoseiid diversity or supporting high densities of important species could be considered for planting and/or conserve hedgerows.

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*Acarologia*, 2003 [2004], XLIV, 1-2 : 31-47.

Predatory mites of the family Phytoseiidae play a fundamental role in controlling phytophagous mites in several crops (Helle and Sabelis, 1985; Lindquist *et al.*, 1996). Their occurrence on natural vegetation has been considered in relation with orchards since the 1950s (e.g. Collyer, 1956; Chant, 1959) and the potential of natural vegetation as a reservoir of predatory mites stimulated a number of studies (e.g. Fauvel & Cotton, 1981; Solomon, 1981; Boller *et al.*, 1988; Grout & Richards, 1990; Lozzia & Rigamonti, 1990; Tuovinen & Rokx, 1991; Coli *et al.*, 1994; Tixier *et al.*, 1998, 2000). Mite communities in vineyards and on the surrounding vegetation were monitored in Northeastern Italy, the population dynamics of the most important families (i.e. Tetranychidae, Tydeidae and Phytoseiidae) being studied for a three-year period (Duso *et al.*, 1993). A complex of five phytoseiid species commonly occurred in the vineyard where tetranychid mites were controlled. The phytoseiids and the tydeids were the mostly abundant mites on natural vegetation, whereas phytophagous mites reached very low levels. The phytoseiids *Amblyseius andersoni* (Chant) and *Euseius finlandicus* (Oudemans) were dominant on the natural vegetation, however *Typhlodromus pyri* Scheuten dominated in the vineyard. More recently, similar investigations were extended to six vineyards and on the vegetation surrounding them. Preliminary reports originating from these surveys have been discussed by Duso & Fontana (1996). The main objective of this research was to identify plant species likely to improve biological control of grapevine pests, by providing refuge, overwintering and alternative food sources for antagonists.

## Materials and Methods

### *Experimental sites and sampling methods*

The study was carried out in six sites of the Veneto region (Northeastern Italy). Two sites were located in a plain: Lancenigo (Piave valley) and Teolo (near Colli Euganei). The other ones being in hilly areas: Zovon (Colli Euganei), Santo Stefano and San Pietro di Barbozza (Valdobbiadene) and Negrar (Valpolicella). In each site a vineyard contiguous to hedgerows or broadleaf stands was selected. Sampling was performed mostly during 1988 and 1989. In these seasons, vineyards were not treated with insecticides or acaricides, except in one case (Lancenigo) where methyl-parathion was erroneously applied in 1989. Downy mildew and powdery mildew were controlled with various fungicides (mostly copper oxychloride, mancozeb, cymoxanil, phosethyl-Al, folpet, and wettable sulphur). Most of them are known to be selective towards phytoseiids (Girolami *et al.*, 1989). A total of 18 plant species were considered (6-10 plants per site). Attention focused especially on elder (*Sambucus nigra* L.), hazel (*Corylus avellana* L.), field maple (*Acer campestre* L.), hop hornbeam (*Ostrya carpinifolia* Scopoli), red dogwood (*Cornus sanguinea* L.), blackberry (*Rubus ulmifolius* Schott) and nettle (*Urtica dioica* L.). The remaining sampled plants were *Acer pseudoplatanus* L., *Alnus glutinosa* Gärtner, *Castanea sativa* Miller, *Ficus carica* L., *Humulus lupulus* L., *Juglans regia* L., *Lamium purpureum* L., *Prunus avium* L., *Quercus pubescens* Willd., *Robinia pseudacacia* L., *Ulmus campestris* Auct.. Some leaf morphology features (density of trichomes on the leaf blade and along the main veins, occurrence and type of domatia, etc.) of these plant species were examined under dissecting microscope. Observations were performed on 20 leaves per plant species; trichome densities were expressed according to frequency classes (i.e. $< 50$ per $cm^2$; 50-100 per $cm^2$, 100-150 per $cm^2$, etc.).

Investigations were carried out in 1988 (Lancenigo, Negrar, San Pietro di Barbozza, Teolo) and 1989 (all the sites) every 15-20 days, from mid-April to mid-September; 50 leaves per plant species were chosen from the middle area of the shoot according to observations on mite distribution (Girolami, 1981; Duso, unpublished data). Leaves were examined in the laboratory under a dissecting microscope to assess mite density. Mites were preserved in Oudemans' fluid and later mounted on slides, usually in Hoyer's medium, to be identified using a phase contrast microscope. Concerning eriophyoids, dried specimens were prepared using the methods described by Jeppson *et al.* (1975) and Nuzzaci & Vovlas (1976). Predatory insects were also monitored. Phytoseiid genera are reported according to Moraes *et al.* (1986) and Chant & McMurtry (1994).

Additional samples were taken in all the sites during 2002. It was not possible to take samples from the vineyard located at Negrar. In the 1990s the use of insecticides (mainly organophosphates and chitin-inhibitors) increased in most vineyards to control *Scaphoideus titanus* (Ball.), vector of the *Flavescence dorée* disease. In the vineyard located at Lancenigo pyrethrins were employed instead of organic insecticides. During 2002, samples were taken in mid-July, late August and early September using the abovementioned procedures.

Differences between phytoseiid densities recorded on wild plants, within each site, were analysed by using the REPEATED option of Proc GLM of SAS (SAS Institute, 1989), and considering the date as a repeated measure (Repeated Measures ANOVA). The means were separated using REGWQ Test, and the significance used in this study was set at a P level of 0.05. For a synthetic presentation of the results, the discussion was focused on analysis of contrasts. Before carrying out an ANOVA logarithmic transformation, i.e. log (y + 1), was applied to the data. Phytoseiid densities were expressed as the number of motile forms per 17.8 $cm^2$ of leaf surface, the average surface of the smallest leaves (*A. campestre*). Data used for these analyses were taken from 1988 and 1989 samples.

### *The diversity in the Phytoseiidae*

Phytoseiid diversity ($D$) was calculated on different wild plants, within each experimental site, using the Margalef index ($D = S — 1/\log N$; where $S$ is the number of species and $N$ is the number of individuals). Phytoseiid communities occurring in vineyards and on wild plants surrounding them where compared using the Coefficient of Similarity proposed by SØRENSEN (SOUTHWOOD, 1978); in particular, $C_s = 2j/(a + b)$, where $j$ is the number of species common to the two samples, $a$ and $b$ are the total number of species in each sample. A modified SØRENSEN Coefficient was also considered (SOUTHWOOD, 1978); in particular, $C_N = 2jN/(aN + bN)$, where $aN$ is the total number of individuals sampled in habitat $a$, $bN$ is the total number of individuals sampled in habitat $b$, and $jN$ is the sum of the lesser values for the species common to both habitats.

## RESULTS

### *Leaf morphology*

Some leaf morphology features of the sampled plants are reported in TABLE 1. The leaf blade of most plants is glabrous or slightly pubescent. *Cornus sanguinea* and *Q. pubescens* are characterised by a moderate leaf pubescence, but in the first case trichomes are very short. In a number of plants leaves show hairy veins and/or tuft domatia. These features, more developed on *A. pseudoplatanus* and *Q. pubescens* than on other species, are positively associated to phytoseiid mite abundance (e.g. WALTER, 1996). The presence of a furrow along the main vein is also commonly associated to the occurrence of phytoseiids.

### *Mites occurring on natural vegetation*

Phytoseiidae and Tydeidae were the main mites collected on natural vegetation. A number of families (Diptilomiopidae, Eriophyidae, Tenuipalpidae, Tetranychidae, Winterschmidtiidae) were recorded at moderate densities. Finally, mites belonging to other families (e.g. Acaridae, Iolinidae, Phytoptidae, Stigmaeidae, Tarsonemidae, Trombidiidae, etc.) were collected less frequently.

Phytoseiidae were collected on all the plants considered. A total of 18 phytoseiid species were found: *Amblyseius andersoni* (Chant), *A. rademacheri* Dosse, *Euseius finlandicus* (Oudemans), *Galendromus* nr. *longipilus* (Nesbitt), *Kampimodromus aberrans* (Oudemans), *K. ericinus* Ragusa & Tsolakis, *K. langei* Wainstein & Arutunjan, *Neoseiulella aceri* (Collyer), *N. tiliarum* (Oudemans), *Neoseiulus reductus* (Wainstein), *Paraseiulus soleiger* (Ribaga), *P. talbii* (Athias-Henriot), *P. triporus* (Chant & Yoshida Shaul), *Phytoseius horridus* Ribaga, *P. plumifer* (Canestrini & Fanzago), *Typhlodromus bakeri* Garman, *T. pyri* Scheuten, *Typhloseiulus simplex* (Chant).

The Tydeoidea were widespread on several plants. In most cases they were abundant in mid- and late season than in early season. The Tydeidae, mainly *Tydeus caudatus* (Dugès) and *T. californicus* (Banks) were commonly recorded. *Lorrya* nr. *teresae* (Carmona) was locally occurring, *Homeopronematus* sp.

| Plant species | Leaf blade | | Vein features | | Domatia | |
|---|---|---|---|---|---|---|
| | glabrous (Y/N) | hair density (No/cm$^2$) | furrow (Y/N) | hair density (No/cm$^2$) | type | hair density within domatia |
| *Acer campestre* | Y | | Y | < 50 | tuft | > 300 |
| *Acer pseudoplatanus* | N | 50-100 | Y | > 300 | tuft | 150-200 |
| *Alnus cordata* | Y | | Y | | tuft | 200-250 |
| *Castanea sativa* | Y | | N | < 50 | | |
| *Cornus sanguinea* | N | > 300 | Y | 100-150 | pit | < 50 |
| *Corylus avellana* | N | < 50 | Y | 100-150 | tuft | < 50 |
| *Ficus carica* | N | < 50 | N | 100-150 | tuft | < 50 |
| *Humulus lupulus* | Y | | Y | | pocket | < 50 |
| *Juglans regia* | Y | | Y | | pit | < 50 |
| *Lamium purpureum* | Y | | Y | < 50 | | |
| *Ostrya carpinifolia* | Y | | Y | 50-100 | tuft | <50 |
| *Prunus avium* | Y | | Y | < 50 | tuft | < 50 |
| *Quercus pubescens* | N | > 300 | Y | 200-250 | tuft | 50-100 |
| *Robinia pseudacacia* | Y | | N | < 50 | | |
| *Rubus ulmifolius* | Y | < 50 | Y | 50-100 | | |
| *Sambucus nigra* | Y | | Y | < 50 | | |
| *Ulmus campestre* | Y | | Y | | tuft | 100-150 |
| *Urtica dioica* | N | 100-150 | Y | 150-200 | pocket | < 50 |

TABLE 1: Leaf features examined on 18 plant species sampled near vineyards in northern Italy.

and *Lorryia* sp., were less frequent, *Triophtydeus lebruni* (André) was also found.

The Tetranychidae were found at low levels. *Tetranychus urticae* Koch was observed especially on *U. dioica* and *R. ulmifolius* and in late season. *Eotetranychus carpini* (Oudemans) was present in very low numbers on *O. carpinifolia* and likewise *Tetranychopsis horrida* (Canestrini & Fanzago) on *C. avellana*. Among the Tenuipalpidae, *Cenopalpus pulcher* (Canestrini & Fanzago) and *Brevipalpus garmani* Baker, were recorded on *P. avium* and *S. nigra* respectively.

Concerning the Eriophyoidea, the Eriophyidae were frequent on *A. campestre* [*Cecidophyes campestris* de Lillo & Fontana and *C. gymnaspis* (Nalepa)], *Acalitus brevitarsus* (Fockeu) was seldom found on *A. glutinosa*. The Diptilomiopidae were commonly collected on *C. sanguinea* (*Diptacus corni* de Lillo & Fontana, *Diptacus sanguineus* de Lillo) and *U. dioica* [*Quadracus urticarius* (Canestrini & Massalongo)].

Among the Winterschmidtiidae, the fungivore *Czenspinskia transversostriata* (Oudemans) was found to be abundant on *C. avellana* but also common on other plants (e.g. *A. campestre*, *R. ulmifolius*, *C. sanguinea*).

*Phytoseiid abundance and diversity in different sites*

SAN PIETRO DI BARBOZZA : During 1988, predatory mite densities were relatively higher in the vineyard at the sprouting and in early August (1.8 and 1.9 motile forms per leaf, respectively). One year later, the phytoseiid population trend was similar (2.7 and 3.2 motile forms per leaf in late April and early August, respectively). In 2002, *T. pyri* was also abundant in late summer (1.36 motile forms per leaf in August). The spider mite *Panonychus ulmi* (Koch) was relatively important only in late 1988. Tydeids were more common in the spring and in late summer. Phytoseiids were widely distributed on wild plants. The effect of plant species on phytoseiid abundance was significant during 1988 ($F = 91.57$; d.f. = 7, 388; $p < 0.0001$) and 1989 ($F = 85.36$; d.f. = 7, 388; $p < 0.0001$). The highest phytoseiid levels were found on *C. avellana* (average 0.81 motile forms per 17.8 cm$^2$ of leaf surface) in 1988, on *S. nigra* (average 0.4 motile forms per 17.8 cm$^2$ of leaf surface) and *U. dioica* (average 0.38 motile forms per 17.8 cm$^2$ of leaf surface) in 1989. Tydeids reached relatively high densities on *A. pseudoplatanus* and *C. sativa* (maximum 0.9 and 0.74 motile forms per 17.8 cm$^2$ of leaf surface, respectively).

**SAN PIETRO DI BARBOZZA**

**Phytoseiid species**

| **Host plants** | | *A. rademacheri* | *E. finlandicus* | *K. aberrans* | *K. ericinus* | *K. langei* | *N. aceri* | *N. tiliarum* | *P. talbii* | *P. plumifer* | *T. pyri* | ***No. of individuals*** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Vitis vinifera* | 1988 | | 1.3 | | | | | | 12 | | 86.7 | 75 |
| | 1989 | | 1.7 | | | | | | 4.7 | | 92.2 | 64 |
| | 2002 | | 1.9 | | | | | | 1.9 | | 96.2 | 104 |
| *Acer campestre* | 1988 | | | | 5.3 | | 94.7 | | | | | 19 |
| | 1989 | | 81.8 | | 4.5 | | 9 | | | | 4.5 | 22 |
| *Acer pseudoplatanus* | 1988 | | 90.9 | | | | 9.1 | | | | | 66 |
| | 1989 | | 68.2 | | 4.5 | | | | | | 27.3 | 22 |
| | 2002 | | 64.5 | 31.8 | | | | | | | 3.7 | 214 |
| *Castanea sativa* | 1988 | | 100 | | | | | | | | | 41 |
| | 1989 | | 100 | | | | | | | | | 14 |
| | 2002 | | 100 | | | | | | | | | 26 |
| *Corylus avellana* | 1988 | | 1.2 | | 2.3 | | | 96.5 | | | | 86 |
| | 1989 | | | | 22.2 | | | 77.8 | | | | 18 |
| | 2002 | | 2.1 | | 97.9 | | | | | | | 142 |
| *Ostrya carpinifolia* | 1988 | | 69.3 | | | 30.6 | | | | | | 62 |
| | 1989 | | 87.5 | | | 12.5 | | | | | | 16 |
| | 2002 | | 34.2 | | | 63.1 | | | | | 2.6 | 38 |
| *Rubus ulmifolius* | 1988 | | 4 | | | | | | | 92 | 4 | 25 |
| | 1989 | | 40 | | | | | | | 40 | 20 | 5 |
| | 2002 | | | | | | | | | 75 | 25 | 8 |
| *Sambucus nigra* | 1988 | | 100 | | | | | | | | | 23 |
| | 1989 | | 95.6 | | | | | | | 4.3 | | 23 |
| | 2002 | | 94.7 | | | | | | | | 5.3 | 113 |
| *Urtica dioica* | 1988 | 34.7 | 10.2 | | 2 | | | | 2 | 46.9 | 4.1 | 49 |
| | 1989 | | | | | | | | | 100 | | 28 |
| | 2002 | | | | | | | | | 100 | | 8 |

TABLE 2: Phytoseiids (percentage and total number of individuals) collected at San Pietro di Barbozza (1988, 1989 and 2002) on the grapevine and the surrounding vegetation.

Three phytoseiid species were collected in the vineyard, being *T. pyri* the most abundant (TABLE 2). Nine phytoseiid species were found on wild plants surrounding the vineyard during 1988, seven species were recorded in 1989 and six species in 2002 (TABLE 2). *Euseius finlandicus* was widespread in all seasons.

LANCENIGO : During 1988, phytoseiids occurring in the vineyard reached maximum levels in early May (1.7 motile forms per leaf). In the subsequent season, phytoseiids were seldom recorded on the grapevine probably due to the application of methyl-parathion. Their densities increased again during 2002 (average 0.64 motile forms per leaf). Among tetranychids, *P. ulmi* and *E. carpini* populations fluctuated at moderate densities (1-3 motile forms per leaf). Tydeids were commonly found in spring. Phytoseiid densities were significant different among wild plants ($F = 97.38$; d.f. = 6, 343; $p < 0.0001$; and $F = 120.51$; d.f. = 5, 294; $p < 0.0001$, for 1988 and 1989 respectively) and they were higher on *C. avellana* during 1988 (average 1.39 motile forms per 17.8 $cm^2$ of leaf surface) and on *A. campestre* during 1989 (average 1.51 motile forms per 17.8 $cm^2$ of leaf surface) than on the remaining plants. Phytoseiid seasonal abundance did not appear to be related to the availability of tetranychids and eriophyoids.

Four phytoseiid species were found in the vineyard (TABLE 3). *Kampimodromus aberrans* was found more continuously than other species. *Typhlodromus pyri* probably originated from a nearby vineyard receiving a release in the late 1980s. Nine phytoseiid species were found on wild plants during 1988, six during 1989, and eight during 2002 (TABLE 3). *Euseius finlandicus* and *A. andersoni* were the most frequent species.

TEOLO: Phytoseiid densities peaked in this vineyard in mid-July (1.18 motile forms per leaf) of 1988 but

**LANCENIGO**

**Phytoseiid species**

| **Host plants** | | *A. andersoni* | *A. rademacheri* | *E. finlandicus* | *K. aberrans* | *K. ericinus* | *K. langei* | *N. aceri* | *N. tiliarum* | *P. soleiger* | *Paraseiulus talbii* | *Phytoseius plumifer* | *P. horridus* | *T. bakeri* | *T. pyri* | ***No. of individuals*** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Vitis vinifera* | 1988 | 28.8 | | | 71.2 | | | | | | | | | | | 118 |
| | 1989 | 25 | | | 50 | | | | | | | 25 | | | | 8 |
| | 2002 | 3.1 | | | 44.4 | | | | | | | | | | 52.4 | 63 |
| *Acer campestre* | 1989 | 47.2 | | 52.8 | | | | | | | | | | | | 36 |
| | 2002 | 0.9 | | 40 | | 7.7 | | 45.8 | | | | | 5.7 | | | 105 |
| *Alnus glutinosa* | 1988 | 12.7 | 9.3 | 76.4 | | | | | | | | 1.8 | | | | 55 |
| | 1989 | | | 94.7 | | | | | 10.2 | | | | | | | 19 |
| | 2002 | | | 92.4 | | 1 | | | | | | | 0.5 | 6.1 | | 195 |
| *Corylus avellana* | 1988 | 7 | | 2.4 | 4 | 75.8 | | | 10.7 | | | 0.8 | | | | 128 |
| | 1989 | 4.3 | | 2.1 | 8.6 | 27.8 | | | 55.9 | | | 2.1 | | | | 47 |
| | 2002 | | | | | 90.2 | 6.1 | | 3.7 | | | | | | | 164 |
| *Lamium purpureum* | 1988 | 76.7 | | 10 | | 3.3 | | | | | | 10 | | | | 30 |
| | 2002 | 15 | | 1 | | | | | | | | 1 | | | | 17 |
| *Rubus ulmifolius* | 1988 | 60.8 | | 14.3 | 14.3 | | | | | | | 10.7 | | | | 28 |
| | 1989 | 47.6 | | 47.6 | | | | | | | | 4.8 | | | | 21 |
| | 2002 | 43.7 | | 21.9 | | 12.5 | | | | | | 21.9 | | | | 32 |
| *Sambucus nigra* | 1988 | 14.3 | | 81.4 | | 2.9 | | | | | 1.4 | | | | | 70 |
| | 1989 | 22.7 | | 77.3 | | | | | | | | | | | | 22 |
| | 2002 | | | 100 | | | | | | | | | | | | 174 |
| *Urtica dioica* | 1988 | 3.6 | | | 1.8 | | | | | 3.6 | | 90.9 | | | | 55 |
| | 1989 | | | | 3.7 | | | | | | | 96.3 | | | | 27 |
| | 2002 | | | | | | | | | | | 100 | | | | 12 |

TABLE 3: Phytoseiids (percentage and total number of individuals) collected at Lancenigo (1988, 1989 and 2002) on the grapevine and the surrounding vegetation.

**TEOLO**

**Phytoseiid species**

| **Host plants** | | *A. andersoni* | *A. rademacheri* | *E. finlandicus* | *K. aberrans* | *K. ericinus* | *N. reductus* | *P. talbii* | *P triporus* | *P. plumifer* | *T. pyri* | ***No. of individuals*** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Vitis vinifera* | 1988 | 59.5 | | 38.1 | | | | 2.4 | | | | 42 |
| | 1989 | 50 | | 4.1 | | | | | | | 45.8 | 24 |
| | 2002 | 65.2 | | 13 | | | | | | | 21.7 | 23 |
| *Castanea sativa* | 1988 | 4.1 | | 91.7 | | | | | | | 4.1 | 24 |
| | 1989 | | | 92 | | | | 8 | | | | 25 |
| | 2002 | | 21.4 | 64.3 | | | | 7.1 | | | 7.1 | 14 |
| *Cornus sanguinea* | 1988 | 10.3 | | 89.7 | | | | | | | | 39 |
| | 1989 | | | 100 | | | | | | | | 12 |
| | 2002 | | | 37.5 | | | | 12.5 | | | 50 | 8 |
| *Ficus carica* | 1989 | | | | | | | | | | 100 | 2 |
| | 2002 | | 3.7 | | 55.6 | 3.7 | | | | 14.8 | 22.2 | 27 |
| *Prunus avium* | 1988 | 4.8 | | 94 | | | | 1.2 | | | | 83 |
| | 1989 | 13 | | 78.3 | | | 4.3 | | | | 4.3 | 23 |
| | 2002 | 47.6 | | 42.8 | | | | 9.5 | | | | 21 |
| *Quercus pubescens* | 1989 | | | 100 | | | | | | | | 9 |
| | 2002 | | | 66.7 | | | | | 33.3 | | | 3 |
| *Robinia pseudacacia* | 1988 | | | 100 | | | | | | | | 1 |
| *Rubus ulmifolius* | 1988 | 7.3 | 24.4 | 2.4 | | 2.4 | | | | 53.7 | 9.8 | 41 |
| | 1989 | 11.8 | 47.1 | | | | | 2.9 | | 38.2 | | 34 |
| | 2002 | 13.6 | 2.3 | 9.1 | | | | | | 27.2 | 47.7 | 44 |
| *Sambucus nigra* | 1988 | 19.5 | | 53.7 | | | | | | | 26.8 | 41 |
| | 1989 | 27.2 | | 54.5 | | | 9.1 | | | | 9.1 | 11 |
| | 2002 | 11.1 | | 88.9 | | | | | | | | 9 |
| *Urtica dioica* | 1988 | | 5.3 | | | | | | | 94.7 | | 38 |
| | 1989 | | 50 | | | | | | | 50 | | 10 |
| | 2002 | | | | | | | | | 100 | | 29 |

TABLE 4: Phytoseiids (percentage and total number of individuals) collected at Teolo (1988, 1989 and 2002) on the grapevine and the surrounding vegetation.

reached low densities (less than 1 motile form per leaf) in 1989 and 2002. *Panonychus ulmi* populations reached moderate levels only in early September 1988. Tydeids were relatively abundant in spring and/or late season. Differences in phytoseiid densities on wild plants were significant (F = 174.91; d.f. = 8, 441; p < 0.0001; and F = 71.61; d.f. = 6, 343; p < 0.0001; for 1988 and 1989 respectively). *Prunus avium* showed the highest values in 1988 (average 0.99 motile forms per 17.8 $cm^2$ of leaf surface), *R. ulmifolius* in 1989 (average 0.42 motile forms per 17.8 $cm^2$ of leaf surface). Tetranychids were rare while eriophyoids were recorded especially on *U. dioica* and *C. sanguinea*. High tydeid populations were recorded on *S. nigra* and *C. sativa*, but especially on *F. carica* (maximum 59.8 motile forms per 17.8 $cm^2$ of leaf surface).

Four phytoseiid species were recorded on the grapevine being *A. andersoni* the most frequent (TABLE 4). Seven phytoseiid species were collected on natural vegetation during 1988 and 1989 and nine species during 2002 (TABLE 4). *Euseius finlandicus* and *A. andersoni* were the most abundant predatory mites. In some cases, the seasonal abundance of phytoseiids was apparently related to that of tydeids (e.g. on *S. nigra* and *C. sanguinea*).

NEGRAR : Predatory mite densities fluctuated at high levels in the vineyard peaking in late summer (18.64 motile forms per leaf in August 1988 and 17.22 motile forms per leaf in October 1989). Tetranychids were never found and tydeids reached low levels (less than 2 motile forms per leaf in some samplings). Differences in phytoseiid densities among wild plants were significant in 1988 (F = 113.70; d.f. = 9, 486; p < 0.0001) and 1989 (F = 120.15; d.f. = 8, 437; p < 0.0001). *Cornus sanguinea* was characterised by the highest population levels in 1988 (average 1.22

**NEGRAR**

**Phytoseiid species**

| **Host plants** | | *A. andersoni* | *A. rademacheri* | *E. finlandicus* | *K. aberrans* | *K. ericinus* | *K. langei* | *N. aceri* | *N. tiliarum* | *P. talbii* | *P. plumifer* | *T. bakeri* | *T. pyri* | ***No. of individuals*** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Vitis vinifera* | 1988 | 1 | | | 99 | | | | | | | | | 202 |
| | 1989 | | | | 88.2 | | | | | 11.8 | | | | 76 |
| *Acer campestre* | 1988 | | | 53.1 | | 34.7 | | 6.1 | | 6.1 | | | | 49 |
| | 1989 | | | 50 | | 50 | | | | | | | | 4 |
| | 2002 | 5.7 | | | | | | 11.4 | | | | | 82.9 | 70 |
| *Cornus sanguinea* | 1988 | 8.2 | | 36.1 | 42.6 | | | | | 1.6 | 9.8 | | 1.6 | 61 |
| | 1989 | | | 73.7 | 10.5 | | | 2.6 | | 7.9 | 2.6 | | 2.6 | 38 |
| | 2002 | | | 55.1 | | | | | | | | | 44.9 | 49 |
| *Corylus avellana* | 1988 | | | 8.7 | | 80.4 | | | 10.9 | | | | | 46 |
| | 1989 | | | 20 | | 50 | | | 25 | | | 5 | | 20 |
| | 2002 | | | 3.6 | | 10.7 | 3.6 | | 82.1 | | | | | 28 |
| *Humulus lupulus* | 1988 | 17.8 | | 81.2 | 1 | | | | | | | | | 107 |
| | 1989 | | | 92 | 4 | | | | | | 4 | | | 25 |
| | 2002 | | | 72 | | | | | | | | | 28 | 25 |
| *Ostrya carpinifolia* | 1988 | 3 | | 33.3 | | | 45.5 | | 3 | | | | 15.1 | 33 |
| | 1989 | | | 16.7 | | | 75 | | 8.3 | | | | | 12 |
| | 2002 | | | 22.7 | | | 50 | | 27.3 | | | | | 22 |
| *Prunus avium* | 1988 | 4.5 | | 88.3 | | | | | | | | | 7.2 | 111 |
| | 1989 | | | 97.8 | | | | | | 2.2 | | | | 45 |
| | 2002 | | | 76.9 | 7.7 | | | | 3.8 | 11.6 | | | | 26 |
| *Robinia pseudoacacia* | 1988 | 10 | | 90 | | | | | | | | | | 10 |
| | 2002 | | | 100 | | | | | | | | | | 2 |
| *Rubus ulmifolius* | 1988 | 6 | | 2 | 12 | | | | 2 | | 70 | | 8 | 50 |
| | 1989 | 3.1 | | | 3.1 | | | | | | 93.8 | | | 32 |
| | 2002 | 3 | 15.2 | 27.4 | | | | | | 3 | 9 | | 42.4 | 33 |
| *Sambucus nigra* | 1988 | 17 | | 71.7 | 5.7 | 1.9 | | | | 1.9 | 1.9 | | | 53 |
| | 1989 | | | 100 | | | | | | | | | | 33 |
| | 2002 | 6.7 | | 33.3 | | | | | | | | | 60 | 15 |
| *Urtica dioica* | 1988 | 1 | 4.1 | | 10.2 | | | | | | 74.5 | | | 98 |
| | 1989 | | | | | | | | | | 100 | | | 30 |
| | 2002 | 50 | | | | | | | | | 50 | | | 4 |

TABLE 5: Phytoseiids (percentage and total number of individuals) collected at Negrar (1988, 1989 and 2002) on the grapevine and the surrounding vegetation.

**SANTO STEFANO**

| Host plants | | *A. andersoni* | *E finlandicus* | *K. ericinus* | *K. langei* | *N. tiliarum* | *P. talbii* | *P. plumifer* | *T. pyri* | *T. simplex* | ***No. of individuals*** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **Phytoseiid species** | | | | | | | | | |
| *Vitis vinifera* | 1989 | | | | | | | | 100 | | 22 |
| | 2002 | | 19.7 | | | | 4.9 | | 75.4 | | 61 |
| *Cornus sanguinea* | 1989 | | | 3.3 | | | 3.3 | | 93.3 | | 30 |
| | 2002 | | 20.3 | | | | 1.7 | | 78 | | 59 |
| *Corylus avellana* | 1989 | 5.1 | 23.1 | 53.8 | | | | 17.9 | | | 39 |
| | 2002 | | 3.5 | 61.8 | 14.1 | 20.6 | | | | | 170 |
| *Juglans regia* | 1989 | | 96.7 | | | 3.3 | | | | | 30 |
| | 2002 | | 100 | | | | | | | | 33 |
| *Ostrya carpinifolia* | 1989 | | | | 75 | | 25 | | | | 4 |
| | 2002 | | 69.4 | | 4.6 | | | | 21.3 | 4.6 | 108 |
| *Rubus ulmifolius* | 1989 | | | | | | | 90.9 | 9.1 | | 11 |
| | 2002 | | 6.7 | | | | | | 93.3 | | 15 |
| *Sambucus nigra* | 1989 | | 50 | | | | | | 50 | | 2 |
| | 2002 | | 80.2 | | | | 1 | | 18.8 | | 101 |

TABLE 6: Phytoseiids (percentage and total number of individuals) collected at Santo Stefano (1988, 1989 and 2002) on the grapevine and the surrounding vegetation.

motile forms per 17.8 $cm^2$ of leaf surface), *S. nigra* and *U. dioica* during 1989 (average 0.58 motile forms per 17.8 $cm^2$ of leaf surface for both plants). Tetranychids were recorded on hop only. Tydeids were common on *S. nigra*, and *A. campestre* (maximum 1.9 and 1.84 motile forms per 17.8 $cm^2$ of leaf surface, respectively). On the latter the dynamics of phytoseiids appeared to be related to that of tydeids.

Three phytoseiid species were found in the vineyard and *K. aberrans* was clearly dominant (TABLE 5). Eleven phytoseiid species were collected on the natural vegetation in 1988 and 1989, ten species in 2002 (TABLE 5). *Euseius finlandicus* was the most abundant species. During 2002, the occurrence of *T. pyri* on natural vegetation was wider than in previous years.

SANTO STEFANO: During 1989, phytoseiids reached low population levels in the vineyard (maximum 0.60-0.64 motile forms per leaf in July and September) while their densities appeared to be higher in 2002. In 1989, *P. ulmi* populations increased in late summer but at non-damaging levels (1.98 motile forms per leaf). Tydeids were not common. On natural vegetation, phytoseiid abundance was affected by plant species ($F = 103.32$; d.f. = 5, 294; $p < 0.0001$) and the highest densities were found on *C. sanguinea* (average 0.62 motile forms per 17.8 $cm^2$ of leaf surface).

In the vineyard *T. pyri* only was recorded during 1989 while *E. finlandicus* and *P. talbii* were also detected in 2002 (TABLE 6). Eight phytoseiid species were found on wild plants during 1989 when *E. finlandicus, K. ericinus* and *T. pyri* were relatively common (TABLE 6). In 2002, phytoseiid complex was somewhat similar to that observed in 1989 (TABLE 6). The most relevant difference concerned the wide distribution of *T. pyri*. Phytophagous mites and tydeids were not common.

ZOVON: During 1989, phytoseiid densities reached low levels (maximum density 0.54 motile forms per leaf in early May) in the vineyard. Population levels appeared to be higher in 2002 (average 1.42 motile forms per leaf). Phytoseiid densities were significantly different among wild plants in 1989 ($F = 83.36$; d.f. = 5, 294; $p < 0.0001$); *C. avellana* and *U. dioica* were characterised by the highest population levels (average 0.33 and 0.37 motile forms per 17.8 $cm^2$ of leaf surface, respectively). Tetranychids and tydeids were seldom collected.

Four phytoseiid species were recorded in the vineyard. *Typhlodromus pyri* was the most frequent during 1989, *A. andersoni* during 2002 (TABLE 7). Four phytoseiid species were found on the natural

**Phytoseiid species**

| **Host plants** | | *A. andersoni* | *E. finlandicus* | *G. longipilus* | *K. aberrans* | *K. ericinus* | *N. tiliarum* | *P. talbii* | *P. plumifer* | *T. pyri* | ***No. of individuals*** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *Vitis vinifera* | 1989 | 10 | | | | | | | | 90 | 10 |
| | 2002 | 63.4 | 9.8 | | | | | 7.3 | | 19.5 | 41 |
| *Corylus avellana* | 1989 | | | | 100 | | | | | | 33 |
| | 2002 | 3.8 | 3.8 | 11.5 | | 7.7 | 11.5 | 3.8 | | 57.7 | 26 |
| *Humulus lupulus* | 1989 | | 92.6 | | | | | | 7.4 | | 27 |
| | 2002 | 11.1 | 22.2 | | | | | 22.2 | | 44.4 | 9 |
| *Prunus avium* | 1989 | | 72.7 | | | | | | 9.1 | 18.2 | 11 |
| | 2002 | 14.3 | | | | | | 28.6 | | 57.1 | 7 |
| *Rubus ulmifolius* | 1989 | | | | 9.1 | | | | 81.8 | 9.1 | 11 |
| | 2002 | 4.5 | | | | | | | 77.3 | 18.2 | 22 |
| *Ulmus minor* | 1989 | | 100 | | | | | | | | 11 |
| | 2002 | | 20 | | | | | | | 80 | 10 |
| *Urtica dioica* | 1989 | | 8.7 | | | | | | 87 | 4.3 | 23 |
| | 2002 | | | | | | | | 100 | | 1 |

TABLE 7: Phytoseiids (percentage and total number of individuals) collected at Zovon (1988, 1989 and 2002) on the grapevine and the surrounding vegetation.

vegetation during 1989, eight species during 2002. In this year *T. pyri* was collected on most plants (TABLE 7).

*The diversity in phytoseiid communities*

The diversity in phytoseiid communities occurring on different plants was measured by the MARGALEF index. Relatively high values of the parameter *D* were observed at Negrar (1988 and 1989) and Teolo (2002) (TABLE 8). *D* values calculated for 1988 and 1989, within each site, were comparable for a number of plant species. In other cases fluctuations were frequently observed (e.g. San Pietro di Barbozza and Teolo). Contrasting data was also observed for a single plant species across the sites (e.g. *C. sativa* at San Pietro di Barbozza and Teolo). In a number of sites, relatively high *D* values were found for *C. avellana* and *R. ulmifolius*. An additional analysis was performed by aggregating the data of 2 (Santo Stefano and Zovon) or 3 years (the remaining sites). The highest *D* values were found for *C. avellana* (1.72 and 0.94 at Zovon and Santo Stefano respectively), *R. ulmifolius* (1.26 at Teolo), *S. nigra* (1.30 at Negrar), *A. glutinosa* (1.26 at Lancenigo), and *U. dioica* (1.26 at San Pietro di Barbozza).

The analysis of the similarity between phytoseiid communities occurring on the grapevine and on wild plants showed relatively high values (0.8-1) of $C_s$ for *C. sanguinea*, *H. lupulus*, *P. avium*, *R. ulmifolius*, *S. nigra*, and *U. dioica* (TABLE 9). However, the relatively low number of species per plant and of individuals per species suggested the use of a modified SØRENSEN Coefficient ($C_N$). $C_N$ values were usually lower than $C_S$ values (TABLE 10). Relatively high $C_N$ values (> 0.5) were recorded for *C. sanguinea, C. sativa* and *P. avium* in some sites or years.

## DISCUSSION

*Phytoseiid mites dominant on wild plants and their economic importance*

In the hedgerows or in margins of stands, *E. finlandicus* dominated among phytoseiids in all sites confirming the results of other surveys carried out in this region (RAGUSA & PAOLETTI, 1985; PAOLETTI & LORENZONI, 1989; PAOLETTI *et al.*, 1989; DUSO *et al.*, 1993). The dominance of *E. finlandicus* over other phytoseiid species may depend on a number of ecological factors, e.g. development and reproduction on a wide range of foods, interspecific and intraspecific competition, and dispersal ability (SCHAUSBERGER, 1997). The occurrence of *E. finlandicus* at moderate densities at Teolo (1988) and Santo Stefano (late summer of 2002) seems to reflect its abundance on the contiguous plants as observed by DUSO *et al.* (1993). In the remaining cases, the low numbers of this pre-

| **Sites** | **Year** | *Acer campestre* | *Acer pseudoplatanus* | *Alnus glutinosa* | *Castanea sativa* | *Cornus sanguinea* | *Corylus avellana* | *Ficus carica* | *Humulus lupulus* | *Juglans regia* | *Lamium purpurea* | *Ostrya carpinifolia* | *Prunus avium* | *Quercus pubescens* | *Robinia pseudacacia* | *Rubus ulmifolius* | *Sambucus nigra* | *Ulmus campestre* | *Urtica dioica* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| San Pietro | 1988 | 0.34 | 0.24 | - | 0 | - | 0.45 | - | - | - | - | 0.24 | - | - | - | 0.62 | 0 | - | 1.28 |
| di Barbozza | 1989 | 0.97 | 0.65 | - | 0 | - | 0.35 | - | - | - | - | 0.36 | - | - | - | 1.24 | 0.32 | - | 0 |
| | 2002 | * | 0.37 | - | 0 | - | 0.2 | - | - | - | - | 0.28 | - | - | - | 0.48 | 0.21 | - | 0 |
| Lancenigo | 1988 | * | - | 0.74 | - | - | 1.03 | - | - | - | 0.88 | - | - | - | - | 0.91 | 0.71 | - | 0.75 |
| | 1989 | 0.27 | - | 0.33 | - | - | 1.29 | - | - | - | * | - | - | - | - | 0.66 | 0.32 | - | 0.31 |
| | 2002 | 0.85 | - | 0.56 | - | - | 0.39 | - | - | - | 0.71 | - | - | - | - | 0.87 | 0 | - | 0 |
| Teolo | 1988 | - | - | - | 0.63 | 0.27 | - | * | - | - | - | - | 0.45 | * | 0 | 1.35 | 0.54 | - | 0.27 |
| | 1989 | - | - | - | 0.31 | 0 | - | 0 | - | - | - | - | 0.96 | 0 | * | 0.85 | 1.25 | - | 0.43 |
| | 2002 | - | - | - | 1.14 | 0.96 | - | 1.21 | - | - | - | - | 0.66 | 0.91 | * | 1.13 | 0.46 | - | 0 |
| Negrar | 1988 | 0.77 | - | - | - | 1.21 | 0.52 | - | 0.42 | - | - | 1.14 | 0.42 | - | 0.43 | 1.27 | 1.25 | - | 0.67 |
| | 1989 | 0.72 | - | - | - | 1.37 | 1.01 | - | 0.62 | - | - | 0.81 | 0.26 | - | * | 0.58 | 0 | - | 0 |
| | 2002 | 0.47 | - | - | - | 0.25 | 0.91 | - | 0.31 | - | - | 0.64 | 0.92 | - | 0 | 1.42 | 0.73 | - | 0.72 |
| Santo | | | | | | | | | | | | | | | | | | | |
| Stefano | 1989 | - | - | - | - | 0.59 | 0.82 | - | - | 0.29 | - | 0.72 | - | - | - | 0.42 | 0.43 | - | - |
| | 2002 | - | - | - | - | 0.49 | 0.82 | - | - | 0 | - | 0.64 | - | - | - | 0.37 | 0.43 | - | - |
| Zovon | 1989 | - | - | - | - | - | 0 | - | 0.3 | - | - | - | 0.83 | - | - | 0.83 | - | 0 | 0.64 |
| | 2002 | - | - | - | - | - | 1.97 | - | 1.37 | - | - | - | 1.03 | - | - | 0.65 | - | 0.43 | 0 |

* not sampled

TABLE 8: Phytoseiid diversity calculated for different wild plants, within each experimental site, using the Margalef index (*D*).

| Sites | Year | *Acer campestre* | *Acer pseudoplatanus* | *Castanea sativa* | *Cornus sanguinea* | *Corylus avellana* | *Humulus lupulus* | *Ostrya carpinifolia* | *Prunus avium* | *Rubus ulmifolius* | *Sambucus nigra* | *Ulmus campestre* | *Urtica dioica* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| San Pietro | 1988 | * | * | * | - | - | - | - | - | 0.67 | * | - | 0.67 |
| di Barboza | 1989 | 0.57 | 0.67 | * | - | - | - | - | - | 0.67 | * | - | * |
| | 2002 | - | 0.67 | * | - | - | - | - | - | * | 0.8 | - | * |
| Lancenigo | 1988 | - | - | - | - | 0.5 | - | - | - | 0.67 | * | - | 0.67 |
| | 1989 | * | - | - | - | 0.67 | - | - | - | 0.67 | * | - | 0.8 |
| Teolo | 1988 | - | - | 0.67 | 0.8 | - | - | - | 1 | * | 0.67 | - | * |
| | 1989 | - | - | * | * | - | - | - | 0.57 | * | 0.86 | - | * |
| | 2002 | - | - | 0.57 | 0.67 | - | - | - | 0.67 | 0.75 | 0.8 | - | * |
| Negrar | 1988 | * | - | - | 0.5 | * | 0.88 | * | * | 0.5 | 0.5 | - | 0.67 |
| | 1989 | * | - | - | 0.5 | * | * | * | * | * | * | - | * |
| Santo Stefano | 1989 | - | - | - | 0.5 | * | - | * | - | 0.67 | 0.67 | - | - |
| | 2002 | - | - | - | 1 | * | - | 0.57 | - | 0.8 | 1 | - | - |
| Zovon | 1989 | - | - | - | - | * | * | - | * | * | - | * | * |
| | 2002 | - | - | - | - | 0.73 | 1 | - | 0.86 | 0.57 | - | 0.67 | * |

* = Coefficient < 0.5

TABLE 9: A comparison of phytoseiid communities occurring in vineyards and on wild plants surrounding them using the Sørensen Coefficient ($C_S$).

| Sites | Year | *Acer campestre* | *Acer pseudoplatanus* | *Castanea sativa* | *Cornus sanguinea* | *Corylus avellana* | *Humulus lupulus* | *Ostrya carpinifolia* | *Prunus avium* | *Rubus ulmifolius* | *Sambucus nigra* | *Ulmus campestre* | *Urtica dioica* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| San Pietro di | 1988 | - | - | - | - | - | - | - | - | 0.04 | - | - | 0.06 |
| Barboza | 1989 | 0.07 | 0.19 | - | - | - | - | - | - | 0.09 | - | - | - |
| | 2002 | - | 0.06 | - | - | - | - | - | - | - | 0.07 | - | - |
| Teolo | 1988 | - | - | 0.51 | 0.49 | - | - | - | 0.34 | - | 0.10 | - | - |
| | 1989 | - | - | - | - | - | - | - | 0.21 | - | 0.14 | - | - |
| | 2002 | - | - | 0.22 | 0.45 | - | - | - | 0.59 | 0.42 | 0.25 | - | - |
| Lancenigo | 1988 | - | - | - | - | 0.11 | - | - | - | 0.29 | - | - | 0.04 |
| | 1989 | - | - | - | - | 0.25 | - | - | - | 0.21 | - | - | 0.09 |
| Negrar | 1988 | - | - | - | 0.22 | - | 0.02 | - | - | 0.06 | 0.04 | - | 0.07 |
| | 1989 | - | - | - | 0.13 | - | - | - | - | - | - | - | - |
| Santo Stefano | 1989 | - | - | - | 0.85 | - | - | - | - | 0.03 | 0.04 | - | - |
| | 2002 | - | - | - | 0.98 | - | - | 0.41 | - | 0.39 | 0.40 | - | - |
| Zovon | 2002 | - | - | - | - | 0.33 | 0.36 | - | 0.15 | 0.08 | - | 0.20 | - |

TABLE 10: A comparison of phytoseiid communities occurring in vineyards and on wild plants surrounding them using a modified Sørensen Coefficient ($C_N$).

dator in vineyards is likely due to its pesticide susceptibility. Other species frequently found on the natural vegetation but rarely found or not recorded in these vineyards were *K. ericinus*, *K. langei*, *N. tiliarum* and *P. plumifer*. In northeastern Italy these species are rarely found in vineyards even if untreated, with the exception of *P. plumifer* on *V. labrusca* varieties (V. Girolami, pers. comm.). *Kampimodromus aberrans* was relatively abundant in two vineyards but not common on natural vegetation. In other investigations carried out in Italy and France, *K. aberrans* was seen to be widespread on natural vegetation close to vineyards (Coiutti, 1993; Cioffi, 2000; Tixier *et al.*, 1998). In France, migration towards vineyards was observed but settlement was not clearly assured (Tixier, 2000; Tixier *et al.*, 2000). In two sites *A. andersoni* was distributed on several plants and in the respective vineyards but this situation was observed during one year only. The case of *T. pyri* appeared to be the most interesting. During the first two experimental years its population densities on the wild vegetation were often low but this species was dominant in 3 vineyards. The abundance of *T. pyri* on plants surrounding vineyards increased in 2002 especially at Negrar, Santo Stefano and Zovon. During this season, the role of natural vegetation as a reservoir of phytoseiids of economic importance involved more *T. pyri* than other species. This data is consistent with the results reported by Boller *et al.* (1988) in Switzerland. It is difficult to ascertain if the larger distribution of *T. pyri* on plants surrounding vineyards observed in 2002 was favoured by the use of insecticides during the 1990s. Ad hoc studies on phytoseiid interchanges between vineyards and natural vegetation are required (Tixier *et al.*, 1998, 2000).

*Factors affecting phytoseiid dominance*

Some phytoseiid species were clearly associated to specific hosts, i.e. *N. aceri* with *Acer* spp., *N. tiliarum* and *Kampimodromus* spp. with *C. avellana*, *P. plumifer* with *U. dioica*. These findings are partially consistent with those of surveys conducted in Italy (Cargnus, 1995; Mazzon *et al.,* 2001; Nicotina & Cioffi, 1998; Cioffi, 2000; Tsolakis *et al.*, 2000). In several cases, the colonization of certain hosts by phytoseiids was clearly associated to leaf morphology. The three *Kampimodromus* species were more common on plants characterized by hairy leaf veins (e.g. *C. avellana*) or showing domatia at the conjunction of the principal vein axils (e.g. *O. carpinifolia*). On the other hand, *E. finlandicus* was often dominant on plants having a glabrous leaf blade (e.g. *C. sativa*, *P. avium*, *S. nigra*) independently of domatia occurrence. Some relations between body size and leaf colonization patterns have been found: phytoseiids occurring on pubescent leaves or frequently found in domatia have usually small size. Some of them belong to the genera *Kampimodromus* and *Phytoseius* (Barret & Kreiter, 1992; Walter, 1992; Duso & Vettorazzo, 1999). Their living in these leaf structures is associated with ideal climatic conditions for hatching and moulting, lower rates of competition, higher pollen retention (Barret & Kreiter, 1992; Duso, 1992; Kreiter *et al.*, 2002). Phytophagous mites are rarely occurring in domatia in contrast with predators and fungivores and thus mutualistic relationships between plants and predatory mites are strongly suggested (Walter, 1996). Large predators such as *E. finlandicus* seem to find optimal conditions on glabrous leaves. Leaves of several plant species present glabrous undersurfaces but also tuft domatia (e.g. *A. campestre*). The presence of two different microhabitats on the same leaf allows for the coexistence of two or more species having different colonization preferences. On maples, *N. aceri* was observed typically in leaf domatia, while *E. finlandicus* preferred to run on blade surfaces. A similar example is reported by Barret & Kreiter (1992) concerning the colonization of *Tilia cordata* L. by *N. tiliarum* and *E. finlandicus*. Domatia are reduced or lacking in other plant species (e.g. *R. pseudacacia*), which are poorly colonized by phytoseiids.

Similar observations can be extended to vineyards. *Kampimodromus aberrans* and *T. pyri* populations reach higher densities on varieties having pubescent leaves than on those characterized by glabrous leaves (Duso, 1992). The latter are colonized more frequently by *A. andersoni* (Camporese & Duso 1996). Data originating from the present study confirm this trend: vineyards of varieties with pubescent leaf undersurfaces were colonized mostly by *K. aberrans* (Lancenigo, Negrar) and *T. pyri* (San Pietro di Barbozza, Santo Stefano, Zovon in 1989). In the remaining vineyard (Teolo), with a variety having glabrous leaf undersurfaces, *A. andersoni* and *E. finlandicus* were found more frequently.

Phytoseiid-host plant associations appeared to be poorly related to the occurrence of their typical prey, i.e. tetranychids and eriophyoids. In contrast, tydeids were constantly recorded on some plants. Tydeids are potential prey for some phytoseiid species (McMurtry *et al.*, 1970; Overmeer, 1985), and optimal prey for others, such as *P. soleiger* and *P. talbii* (Dosse, 1956; Camporese & Duso, 1995). The latter were scarcely represented on natural vegetation while the seasonal abundance of some common predatory mites sometimes appeared to be related to that of tydeids (e.g. *E. finlandicus* on *Acer* spp., *C. sativa* and *S. nigra*). Among the remaining mite groups encountered in this survey, we could mention tenuipalpids and winterschmidtiids. The former are an important source of foods for some phytoseiids (McMurtry *et al.*, 1970; Kostiainen & Hoy, 1996), while the role of winterschmidtiids is scarcely documented (Dosse, 1956; Knisley & Swift, 1971). Feeding on small insects, honeydew and mould can improve phytoseiid survival but the effects of these food sources are known in a limited number of cases, including *E. finlandicus* (Kropczynska-Linkiewicz, 1971; Tanigoshi, 1982; Schausberger, 1997). A number of species found in this survey can develop and reproduce on pollen (McMurtry & Croft, 1997) and it is reasonable that phytoseiid persistence on natural vegetation is strongly affected by pollen availability. A significant effect of certain fungi on phytoseiid biology has been reported for some of species reported in the present study (Chant, 1959; Kropczynska-Linkiewicz, 1971; Daftari, 1979; Bakker, 1993; Zemek & Prenerova, 1997; Duso *et al.*, 2003). The preference for a host plant by a phytoseiid species could be also related to the capacity of piercing leaf cells. This event, reported by Chant (1959) and Kreiter *et al.* (2002) for *K. aberrans*, may have great implications for phytoseiid persistence.

During 1988 and 1989 the phytoseiid species found to be more abundant in vineyards were *T. pyri*, *A. andersoni* and *K. aberrans*. In 2002 these species were confirmed as dominant even if *K. aberrans* and *A. andersoni* were not abundant. Unfortunately, we have no data for Negrar where *K. aberrans* was widespread in the past. Apparently, the increased use of organic insecticides in the 1990s did not affect phytoseiid communities in these vineyards, in particular those colonized by *T. pyri* and *A. andersoni*. Both species are known to be resistant to a number of insecticides (Duso *et al.,* 1992). The strain of *K. aberrans* occurring at Lancenigo was seen to be susceptible to OPs (Duso, unpublished data). Its persistence is most likely due to the use of pyrethrins instead of organic insecticides.

*Plant species with a potential role in promoting phytoseiid diversity and abundance*

Eighteen phytoseiid species were recorded on the vegetation surrounding the vineyards under examination. The number of phytoseiid species found in each site ranged from 9 to 14. These values are close to those found in previous studies carried out in the same area (11 species in a single agro-ecosystem, Duso *et al.*, 1993) and higher than those found in other studies carried out in northern Italy (5 species in various agro-ecosystems, Lozzia and Rigamonti, 1990) and Switzerland (7 species in various agro-ecosystems, Boller *et al.*, 1988). More diversified phytoseiid complexes have been found in southern Italy (16 species in a single agro-ecosystem, Cioffi, 2000) and southern France (14 species in a single agro-ecosystem, Tixier, 2000).

Plant species composition and structure, their proximity to vineyards, and the management of the latter (especially pesticide use) are obvious factors affecting the diversity of phytoseiid species occurring on wild plants. It was not possible to compare phytoseiid diversity across the sites because of their marked differences (plant species number, vegetation structure, climate, etc.). An analysis of communities recorded on different plants (within each site) showed that phytoseiid diversity was often higher on *C. avellana* and *R. ulmifolius* than on other plants. At the same time, phytoseiid communities occurring on *C. sanguinea, C. sativa* and *P. avium* were more similar than others to those of the grapevine, at least in some sites or years. This data suggests a role of these plants as a reservoir of phytoseiids for vineyards even if additional information is needed.

Planning a new hedgerow plantation clearly depends on the type of farm (organic or conventional, etc.) or the farming goals, i.e. protection from wind, increase of wood production, reduction of nutrient releases, promotion of apiculture, etc. Biological control is considered with attention in organic farms only. The role of plants as reservoirs for phytoseiids is only a part of the total expected biological control functions, since grape moths and leafhoppers (assumedly unaffected by phytoseiids) cause the most frequent problems to European vineyards. Most of the plants encountered in this study showed positive features for this purpose. *Corylus avellana* provides large amounts of pollen early in the season, potentially used by overwintering phytoseiids and other beneficials, including honeybees. This plant is colonized by specific eriophyoids and tetranychids, winterschmidtiids and aphids (honeydew) for long periods, and it is frequently infected by powdery mildew. *Corylus avellana* is frequently colonized by the same phytoseiid species occurring in vineyards, i.e. *K. aberrans* (Coiutti, 1993; Cioffi, 2000) and, to a lesser extent, *T. pyri* (Boller *et al.*, 1988). Other plants provide large amounts of pollen (e.g. *C. sanguinea*, *O. carpinifolia* and *S. nigra*) or support a wide range of non-damaging mite species (e.g. *Acer* spp.). The positive role of *R. ulmifolius* and *U. dioica* in providing habitats for parasitoids and predators is also well known (Arzone *et al.*, 1988; Cerutti *et al.*, 1989; Sommaggio *et al.*, 1995). However, the management of these two plants is difficult. Some plant species (e.g. *C. avellana*, *C. sanguinea*, and *S. nigra*) were often characterised by high densities of phytoseiids. During 1988 and 1989 the predatory mites dominant on these plants were seldom those considered important for vineyards. However, the results obtained during 2002 suggest a major role of some wild plant species (e.g. *C. sanguinea* and *S. nigra*) in the conservation of *T. pyri* populations.

Implications of these findings require additional studies. The settlement of predatory mites occurring on natural vegetation into vineyards seems to be hardly menaced because of their susceptibility to conventional pesticides. It is likely that predatory mites living on wild plants close to vineyards may have some contacts with chemicals because of the spray drifting. This is assumed to be especially true of hedgerows and stand margins. The effects of pesticides on predatory mites should involve also strains originating from natural vegetation. Furthermore, population genetics will give a fundamental contribution in assessing the real potential of natural vegetation for biological control (Tixier *et al.*, 2002).

## Acknowledgement

The work was partially supported by the MURST-MIUR. We thank M. Castagnoli, E. de Lillo, and M. Pagani for the identification of a number of Tydeoidea, Tenuipalpidae, Eriophyoidea and Winterschmidtiidae, respectively. We also thank V. Girolami and S. Ragusa for helping us in the identification of *K. ericinus* and *K. langei.*

## REFERENCES

Arzone (A.), Vidano (C.) & Arnò (C.), 1988. — Predators and parasitoids of *Empoasca vitis* and *Zygina rhamni* (Rhynchota Auchenorryncha). — In: C. Vidano and A. Arzone (Eds.), Proceedings of 6th. Auchenorryncha Meeting, Turin, Italy, 7-11 Sept. 1987, pp. 623-629.

Bakker (F.M.), 1993. — Selecting phytoseiid predators for biological control, with emphasis on the significance of tri-trophic interactions. — PhD Thesis, University of Amsterdam, The Netherlands, pp. 132.

Barret (D.) & Kreiter (S.), 1992. — Rôles des relations morphométriques dans la coopération entre certaines plantes et des acariens prédateurs Phytoseiidae (Acari). — Bull. Soc. Ecophysiol., **17**: 129-143.

Boller (E.F.), Remund (U.) & Candolfi (M.P.), 1988. — Hedges as potential sources of *Typhlodromus pyri*, the most important predatory mite in vineyards of northern Switzerland. — Entomophaga, **33**: 249-255.

Camporese (P.) & Duso (C.), 1995. — Life history and life table parameters of the predatory mite *Typhlodromus talbii*. — Entomol. Exp. App., **77**: 149-157.

Camporese (P.) & Duso (C.), 1996. — Different colonization patterns of phytophagous and predatory mites (Acari: Tetranychidae, Phytoseiidae) on three grape varieties: a case study. — Exp. Appl. Acarol., **20**: 1-22.

Cargnus (E.), 1995. — Fitoseidi di piante arboree ed arbustive: distribuzione e caratteristiche genetico-morfologiche. — Ph. D. Thesis, Università degli Studi di Udine, Italia, 125 pp.

Cerutti (F.), Delucchi (V.), Baumgartner (J.) & Rubli (D.), 1989. — Ricerche sull'ecosistema "vigneto" nel

Ticino: II. La colonizzazione dei vigneti da parte della cicalina *Empoasca vitis* Goethe (Hom., Cicadellidae, Typhlocybinae) e del suo parassitoide *Anagrus atomus* Haliday (Hym., Mymaridae) e importanza della flora circostante. — Mitt. Schweiz. Ent. Ges., **62**: 253-267.

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 38 new species. — Can. Ent. **91**, suppl. **12**: 1-166.

CHANT (D.A.) & MCMURTRY (J.A.), 1994. — A review of the subfamilies Phytoseiinae and Typhlodrominae (Acari: Phytoseiidae). — Internat. J. Acarol., **20**: 223-310.

CIOFFI (E.), 2000. — Composizione, fluttuazione e interrelazioni del complesso di acari Fitoseidi (Parasitiformes, Phytoseiidae) vincolato ad un'area agro-forestale della Val Comino (Lazio). — Ph. D. Thesis, Università degli Studi di Napoli, Italia, 64 pp.

COIUTTI (C.), 1993. — Acari Fitoseidi su piante arboree spontanee e coltivate in Friuli-Venezia Giulia. — Fru. Entomol., **16**: 65-78.

COLI (W.M.), CIURLINO (R.A.), & HOSMER (T.), 1994. — Effect of understory and border vegetation composition on phytophagous and predatory mites in Massachusetts commercial apple orchards. — Agr. Ecosyst. Environ., **50**: 49-60.

COLLYER (E.), 1956. — Notes on the biology of some predacious mites on fruit trees in South-Eastern England. — B. Entomol. Res., **47**: 205-214.

DAFTARI (A.), 1979. — Studies on feeding, reproduction, and development of *Amblyseius aberrans* (Acarina: Phytoseiidae) on various food substances.— Z. Angew. Ent., **88**: 449-453.

DOSSE (G.), 1956. — Über die Entwicklung einiger Raubmilben bei verschiedenen Nahrungstieren (Acar., Phytoseiidae). — Pflanzenschutzber., **16**: 122-136.

DUSO (C.), 1992. — Role of *Amblyseius aberrans* (Oud.), *Typhlodromus pyri* Scheuten and *Amblyseius andersoni* (Chant) in vineyards. III. Influence of variety characteristics on the success of *A. aberrans* and *T. pyri* releases. — J. Appl. Ent., **114**: 455-462.

DUSO (C.) & FONTANA (P.), 1996. — Mite communities on wild plants surrounding vineyards in North-Eastern Italy with special emphasis on phytoseiids (Acari: Phytoseiidae). — In: Mitchell R., Horn D.J., Needham G.R. and W.C. Welbourn (Eds.), Proc. IX International Congress of Acarology, 17-22 July 1994, Columbus, Ohio, pp. 261-264.

DUSO (C.) & VETTORAZZO (E.), 1999. — Mite population dynamics on different grape varieties with or without phytoseiids released (Acari: Phytoseiidae). — Exp. Appl. Acarol., **23**: 741-763.

DUSO (C.), CAMPORESE (P.) & VAN DER GEEST (L.P.S.), 1992. — Toxicity of a number of pesticides to strains of *Typhlodromus pyri* and *Amblyseius andersoni* (Acari: Phytoseiidae). — Entomophaga, **37**: 363-372.

DUSO (C.), TORRESAN (L.) & VETTORAZZO (E.), 1993. — La vegetazione spontanea come riserva di ausiliari: considerazioni sulla diffusione degli Acari Fitoseidi (Acari Phytoseiidae) in un vigneto e sulle piante spontanee contigue. — Boll. Zool. Agr. Bachic., **25**: 183-203.

DUSO (C.), POZZEBON (A.), CAPUZZO (C.), BISOL (P.M.) & OTTO (S.), 2003. — Grape Downy Mildew Spread and Mite Seasonal Abundance in Vineyards: Evidence for the Predatory Mites *Amblyseius andersoni* and *Typhlodromus pyri*. — Biological control **27**: 229-241.

FAUVEL (G.) & COTTON (D.), 1981. — The evolution of typhlodromid populations mainly *Amblyseius aberrans* Oud. (Acari: Phytoseiidae) in an elm hedge and in an apple orchard with some observations on their transport by wind. — C.R. 6ᵉs Journées Phytiatr. Phytopharm. Circumm., Perpignan (France), 25-28 Mai 1981, pp. 471-479.

GIROLAMI (V.), 1981. — Danni, soglie di intervento, controllo degli acari della vite. — Atti convegno "III incontro su la difesa integrata della vite," Latina, 3-4 dicembre 1981, Regione Lazio: 111-143.

GIROLAMI (V.), DUSO (C.), REFATTI (E.) & OSLER (R.), 1989. — Lotta integrata in viticoltura. Malattie della vite. — I.R.I.P.A., Venezia-Mestre., pp. 98.

GROUT (T.G.) & RICHARDS (G.I.), 1990. — The influence of windbreak species on citrus thrips (Thysanoptera: Thripidae) populations and their damage to South African citrus orchards. — J. Entomol. Soc. S. Africa, **53**: 151-157.

HELLE (W.) & SABELIS (M.W.), 1985. — Spider Mites. Their biology, natural enemies and control. — 1B. World crop pests (W. Helle Ed.), Elsevier, Amsterdam, pp. 458.

JEPPSON (L.R.), KEIFER (H.H.) & BAKER (E.W.), 1975. — Mites injurious to economic plants. — Univ. Calif. Press, Berkeley, California, USA, pp. 614.

KNISLEY (C.B.) & SWIFT (F.C.), 1971. — Biological studies of *Amblyseius umbraticus* (Acarina: Phytoseiidae). — Ann. Entomol. Soc. Am., **64**: 813-822.

KOSTIAINEN (T.S.) & HOY (M.A.), 1996. — The Phytoseiidae as biological control agents of pest mites and insects. A bibliography. — Monograph 17, Florida Agricultural Experiment Station, pp. 355.

KREITER (S.), TIXIER (M. S.), CROFT (B.A.), AUGER (P.) & BARRET (D.), 2002. — Plants and leaf characteristics influencing the predaceous mite *Kampimodromus aberrans* (Acari: Phytoseiidae) in habitats surrounding vineyards. — Environ. Entomol., **31**: 648-660.

KROPCZYNSKA-LINKIEWICZ (D.), 1971. — Studies on the feeding of four species of phytoseiid mites (Acarina:

Phytoseiidae). — Proceedings 3rd International Congress of Acarology, Prague, pp. 225-227.

LINDQUIST (E.E.), SABELIS (M.W.) & BRUIN (J.), 1996. — Eriophyoid mites. Their biology, natural enemies and control. — World crop pests (W. Helle Ed.), Elsevier, Amsterdam, pp. 790.

LOZZIA (G.C.) & RIGAMONTI (I.E.), 1990. — Influenza dell'ambiente e delle tecniche agrocolturali sulla presenza dei Fitoseidi (Acarina: Phytoseiidae) in alcuni vigneti del Nord Italia. — Atti Giornate Fitopatologiche 1990: 449-458.

MAZZON (L.), CARGNUS (E.) & GIROLAMI (V.), 2001. Indagini su distribuzione, piante ospiti e dinamica di popolazione di *Kampimodromus langei* Wainstein & Arutunjan (Acari Phytoseiidae). — Fru. Entomol. **XXIV**: 117-124.

MCMURTRY (J.A.) & CROFT (B.A.), 1997. — Life-styles of phytoseiid mites and their roles in biological control. — Ann. Rev. Entomol., **42**: 291-321.

MCMURTRY (J.A.), HUFFAKER (C.B.) & VAN DE VRIE (M.), 1970.— Ecology of tetranychid mites and their natural enemies: a review. I. Tetranychid enemies: their biological characters and the impact of spray practices. — Hilgardia, **40**: 331-390.

MORAES DE (G.J.), MCMURTRY (J.A.) & DENMARK (H.A.), 1986. — A catalogue of the mite family Phytoseiidae. References to taxonomy, synonymy, distribution and habitat. — Embrapa DF, Brasilia, pp. 353.

NICOTINA (M.) & CIOFFI (E.A.), 1998. — Distribution of phytoseiid mites (Acarina Phytoseiidae) in *C. avellana*-nut-growing areas in Campania. — Redia, **81**: 115-124.

NUZZACI (G.) & VOVLAS (N.), 1976. — Osservazione dei caratteri tassinomici degli Eriofidi al microscopio elettronico a scansione. — Proc. XI Congr. Naz. It. Ent., Portici-Sorrento, 10-15 maggio 1976, pp. 117-122.

OVERMEER (W.P.J.), 1985. — Alternative prey and other food resources. In: W. Helle and M.W. Sabelis, Spider Mites. Their biology, natural enemies and control. 1B. — World Crop Pests, Elsevier, Amsterdam, pp. 131-139.

PAOLETTI (M.G.) & LORENZONI (G.G.), 1989. — Agroecology patterns in Northeastern Italy. — Agric. Ecosyst. Environ., **27**: 139-154.

PAOLETTI (M.G.), FAVRETTO (M.R.), RAGUSA (S.) & ZUR STRASSEN (R.), 1989. — Animal and plant interactions in the agroecosystems. The case of woodland remnants in Northeastern Italy. — Ecol. Int. Bull., **17**: 79-91.

RAGUSA (S.) & PAOLETTI (M.G.), 1985. — Phytoseiid mites of corn and soybean agroecosystems in the low-laying plain of Veneto (N-E Italy). — Redia, **68**: 69-89.

SCHAUSBERGER (P.), 1997. — Inter- and intraspecific predation on immatures by adult females in *Euseius finlandicus*, *Typhlodromus pyri* and *Kampimodromus aberrans* (Acari: Phytoseiidae). — Exp. Appl. Acarol., **21**: 131-150.

SOLOMON (M.G.), 1981. — Windbreaks as a source of orchard pests and predators. — In: J.M. Thresh (Ed.), Pest, pathogens and vegetation. Pitman Advanced Publishing Program, Boston, London, Melbourne, pp. 273-283.

SOMMAGGIO (D.), PAOLETTI (M.G.) & RAGUSA (S.), 1995. — The effects of microhabitat conditions, nutrients and predators on the abundance of herbivores on stinging nettle (*Urtica dioica* L.). — Acta Oecol., **16**: 671-686.

SOUTHWOOD (T.R.E.), 1978. — Ecological methods with particular reference to the study of insect populations. — Chapman and Hall, London and New York, pp. 524.

TANIGOSHI (L.K.), 1982. — Advances in knowledge of the biology of the Phytoseiidae. In: M.A. Hoy (Ed.), Recent advances in knowledge of the Phytoseiidae. — Div. Agric. Sci. Spec. Publ. 3284. Univ. California, Berkeley, USA: 1-22.

TIXIER (M.-S.), 2000. — La présence de Phytoséiides dans les abords non cultivés des parcelles a-t-elle un intérêt appliqué en viticulture?— Ph. D Thesis, Ecole Nationale Supérieure Agronomique de Montpellier, France, pp. 189.

TIXIER (M.-S.), KREITER (S.), AUGER (P.) & WEBER (M.), 1998. — Colonization of Languedoc vineyards by phytoseiid mites (Acari: Phytoseiidae): influence of wind and crop environment. — Exp. Appl. Acarol., **22**: 523-542.

TIXIER (M.-S.), KREITER (S.) & AUGER (P.), 2000. — Colonization of vineyards by phytoseiid mites: their dispersal patterns in the plot and their fate. — Exp. Appl. Acarol., **24**: 191-211.

TIXIER (M.-S.), KREITER (S.), CROFT (B.A.) & AUGER (P.), 2002. — Colonization of vineyards by *Kampimodromus aberrans* (Oudemans) (Acari: Phytoseiidae): dispersal from surrounding plants as indicated by random amplified polymorphism DNA typing. — Agricultural and Forest Entomology, **4**: 255-264.

TSOLAKIS (H.), RAGUSA (E.) & RAGUSA DI CHIARA (S.), 2000. Distribution of phytoseiid mites (Parasitiformes, Phytoseiidae) on C. avellananut at two different altitudes in Sicily (Italy). — Environ. Entomol., **29**: 1251-1257.

TUOVINEN (T.) & ROKX (J.A.H.), 1991. — Phytoseiid mites (Acari: Phytoseiidae) on apple trees and in surrounding vegetation in southern Finland. — Exp. Appl. Acarol., **12**: 35-46.

WALTER (D.E.), 1992. — Leaf surface structure and the distribution of *Phytoseius* mites (Acarina: Phytoseiidae) in South-eastern Australian forests. — Aust. J. Zool., **40**: 593-603.

WALTER (D.E.), 1996. — Living on leaves: mites, tomenta, and leaf domatia. — Annu. Rev. Entomol., **41**: 101-114.

ZEMEK (R.), PRENEROVA (E.), 1997. — Powdery mildew (Ascomycotina: Erysiphales) an alternative food for the predatory mite *Typhlodromus pyri* Scheuten (Acari: Phytoseiidae). — Exp. Appl. Acarol., **21**: 405-414.