Does agroforestry affect phytoseiid mite communities in vineyards in the South of France?

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The abundance and diversity of phytoseiid mites were surveyed from April to September 2003-2005 in several grape crops in the South of France, with Grenache and Syrah cultivars, co-planted with rows of *Sorbus domestica* or *Pinus pinea* and in plots with monocultures of grapes. Densities of phytoseiid mites differed on the two tree species. *Pinus pinea* seemed to be a better host than *S. domestica*. *Typhlodromus exhilaratus* was the dominant species in the crops and on co-planted rows of *S. domestica* and *P. pinea*, whereas *T. phialatus* was the most abundant species in plots with monocultures of trees. Agroforestry management does not seem to affect mite diversity in vine plots. The densities of phytoseiid mites in vine crops may well be affected by the co-plantation of trees, especially in 2005. Although the densities observed during 2003 and 2004 were probably low due to very dry and hot climatic conditions, the agroforestry management seems to have had a significant impact on mite densities in 2005. Further experiments should be carried out to confirm this effect.

Key words: Phytoseiidae, *Typhlodromus exhilaratus*, *Typhlodromus phialatus*, vineyards, *Pinus pinea*, *Sorbus domestica*

This study deals with the impact of crop floristic diversification on phytoseiid mite communities in vineyards in the South of France. Many phytoseiid species are natural enemies well-known for their efficiency in controlling crop pests (McMurtry & Croft, 1997).

Plant diversity in uncultivated areas surrounding crops may increase natural enemy occurrence (density and diversity) (Altieri & Letourneau, 1982; Escudero & Ferragut, 1999; Zacarias & Moraes, 2002). Diversification of agrosystems could be achieved by the management of crop borders or of the vegetation inside the crop fields (Flaherty, 1969; Boller et al., 1988; Coli et al., 1994; Tsolakis et al., 1997; Lozzia & Rigamonti, 1998; Kreiter et al., 2000; Tixier et al., 2000a,b; Nicholls et al., 2001; Duso et al., 2004; Barbar et al., 2005).

Agroforestry management modifies microclimatic conditions, creates alternative habitats and foods, thereby affects arthropod diversity (Stamps & Linit, 1998). Although some studies have shown the importance of agroforestry system (trees and/or shrubs combined with crops) in pest management (Linit & Stamps, 1995; Altieri & Nicholls, 2002), little is known about the impact of agroforestry systems on communities of predatory mites in vineyards.

The present study aims to test the hypothesis that agroforestry grape plots have higher mite abundance and diversity than monocultural grape plots.

MATERIAL AND METHODS

The study site

The experiments took place in vine crops in Restinclières (15 km north of Montpellier, Hérault, France). Here two cultivars, Syrah and Grenache, were planted in 1997 on a reclaimed fallow (30 years old). Rows of *Sorbus domestica* L. and *Pinus pinea* L. were also planted within crops in 1997. Five to six phytosanitary treatments per year were applied (fungicides against powdery mildew and downy mildew, insecticides against *Scaphoideus titanus* Ball), with pesticides selected for their minimal side effects on phytoseiid mites, when possible. No acaricide was used during the 3-year study or before. Grape crops were surrounded by uncultivated areas mainly composed of *Pinus halepensis* Viller and *Quercus coccifera* L. Two kind of plots were included in the surveys: (1) plots including rows of *S. domestica* (grape crop I) or rows of *P. pinea* (grape crop II), (2) control plots comprising only grape, only *S. domestica*, or only *P. pinea* (Table 1).

Sampling

Sampling was done from April to September, 5× in 2003, 6× in 2004, and 3× in 2005. In grape crops I and II, 30 leaves per row of grape, *S. domestica*, and *P. pinea* (a branch of 10 cm of pine was considered the equivalent of a leaf) were collected randomly. In monocultures 60 leaves per plot were sampled. Leaves were put in plastic bags and brought back to the laboratory in a freezer. Phytoseiid mites were counted and removed from each leaf of grape and *S. domestica* using a binocular microscope at 40× magnification. For mite extraction from each twig of *P. pinea* Boller's (1984) 'dipping-checking-washing-filtering' method was used. To compare phytoseiid densities found on *P. pinea*, *S. domestica*, and vine, leaves were dried in a sterilizer at 50 °C during 2 days and then weighted. Phytoseiid abundance was recorded as numbers of phytoseiids per g dried leaves (Majer & Recher, 1988).

Mite identifications

All mites were slide-mounted in Hoyer's medium and identified with a phase-contrast and interferential contrast microscope, based on the taxonomic keys of the generic revisions of Typhlodrominae, Phytoseiinae, and Amblyseiinae (*Ambly-*

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Table 1 Characteristics of the sampled plots in the study site of Restinclières (Hérault-France).

	Experimental grape crop I	Experimental grape crop II	Monocultural grape crop	*P. pinea*	*S. domestica*
Surface (m²)	4,600	3,900	1,000	3,400	2,500
Plantation density (m)	2.5 × 1	2.5 × 1	2.5 × 1	3 × 2	4 × 3
Syrah cultivar (rows)	11	10	9	-	-
Grenache cultivar (rows)	9	12	11	-	-
Rows of *Sorbus domestica*	4	-	-	-	5
Rows of *Pinus pinea*	-	5	-	12	-

Table 2 Results of variance analysis and mean comparison test (α = 0.05) on phytoseiid mite densities in sampled grape crops in Restinclières (Hérault - France).

Comparison	Kruskal-Wallis test	Newman-Keuls mean mite density	
Sampling date	P<0.001	2003	0.10b
		2004	0.06c
		2005	0.22a
Grape cultivars	P<0.001	Grenache	0.07b
		Syrah	0.14a
Grape crops	P = 0.05	Experimental grape crop I	0.11a
		Experimental grape crop II	0.10a
		Monocultural grape crop	0.10a

Means sharing a letter (within a 'comparison') are not significantly different.

seiini, *Neoseiulini*, *Kampimodromini*) (Chant & McMurtry, 1994, 2003a,b, 2004), and the catalogue of Moraes et al. (2004) for all other genera of Amblyseiinae.

Data analysis

Variance analysis (Kruskal-Wallis test), followed by a Newman-Keuls mean comparison test (α = 0.05) (Statistica® version 7.1, 2005) were carried out to compare (1) mite density on vine, in grape crops I and II (agroforestry), and in the monocultural grape crops, (2) mite density on *S. domestica* and *P. pinea* rows in grape crops I and II, and in plots with tree monocultures, (3) mite density on the two grape cultivars, and (4) mite density on *S. domestica*, *P. pinea*, and grape (no. mites/g leaf dry weight).

RESULTS

Phytoseiid mite abundance in vine crops with and without agroforestry management

During 3 years, phytoseiid mites were found in all grape crops studied. Highest densities were observed in 2005 (mean no./leaf = 0.22) and the lowest in 2004 (mean no./leaf = 0.10) (Table 2). Mite densities in agroforestry-managed grape crops and those in monoculture groups did not differ significantly when the 3 years were grouped ($H_{2,18185}$ = 6.05, P>0.05; Table 2). However, within each year, there were differences. In 2003, mite abundance did not differ between grape crop I and the grape monoculture, but a significant difference ($H_{2,6568}$ = 141.97, P<0.001) was found between these two plots and grape crop II, with the lowest densities. In 2004, mite densities were highest in grape crop II ($H_{2,8313}$ = 47.78, P<0.0001), but densities remained altogether low during this year. In 2005, densities were different in the three grape crops, with the higher densities in the agroforestry-managed grape crops I and II ($H_{2,3300}$ = 15.28, P = 0.0005).

In all grape crops (agroforestry-managed or monoculture), mite densities were higher on Syrah than on Grenache ($H_{1,18185}$ = 98.78, P<0.001; Table 2). The two cultivars have very different leaf architecture and this observation confirms the association between leaf characteristics (pilosity and domatia) and development (i.e., survival, fecundity) of various phytoseiid species (Duso & Vettorazzo, 1999; Kreiter et al., 2002).

Phytoseiid mite abundance on *Sorbus domestica* and *Pinus pinea*

Phytoseiid density on *S. domestica* (co-planted or not) was very low during the 3 years. On *P. pinea* a significant difference in phytoseiid density was observed between the two modalities (co-planted or not), when grouping the 3 year samples ($H_{1,2891}$ = 86.87, P<0.001) or not (2003: $H_{1,1250}$ = 15.87, P = 0.001; 2004: $H_{1,1200}$ = 112.06, P<0.001; 2005: $H_{1,525}$ = 12.73, P<0.0001).

Phytoseiid mite densities on *Pinus pinea*, *Sorbus domestica* and vine plants

Mite density on *P. pinea* (co-planted or not) during 3 years was significantly higher than on *S. domestica* ($H_{5,22088}$ = 523.85, P<0.001). The highest densities were found in the *P. pinea* monoculture, then on *P. pinea* co-planted in grape crop II. Mite densities in the *P. pinea* monoculture were not significantly different from densities found on grape cv. Syrah.

Phytoseiid mite diversity

In all grape crops (agroforestry or not), *Typhlodromus* (*T.*) *exhilaratus* Ragusa prevailed (>98%) (Fig. 1). The other species [*Typhlodromus* (*T.*) *phialatus* Athias-Henriot, *Paraseiulus triporus* (Chant & Yoshida-Shaul), *Typhlodromus* (*T.*) *pyri* Scheuten] were only observed in vine plots in 2003.

Five phytoseiid species were found on co-planted *P. pinea*: *T. exhilaratus* (87%), *T. phialatus* (12%), and sporadically *Typhlodromus* (*Anthoseius*) *recki* (Wainstein), *Kampimodromus aberrans* (Oudemans) and *Neoseiulus bicaudus* (Wainstein). In the *P. pinea* monoculture, the main species was *T. phialatus* (97%).

Typhlodromus exhilaratus was the only species found on co-planted trees of *S. domestica*, whereas *T. phialatus* was the main species in the monoculture of *S. domestica* (67%).

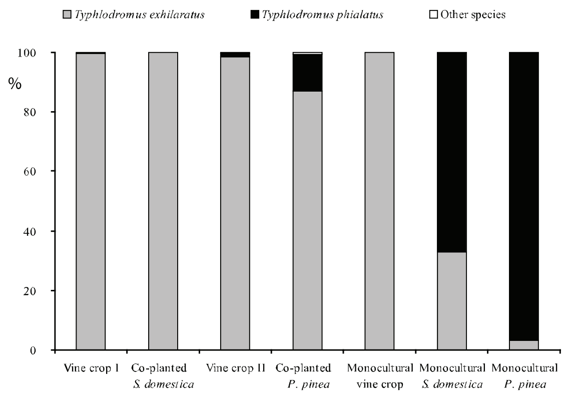

Figure 1 Distribution of Phytoseiid mite species (%) in the sampled plots in the study site of Restinclières (Hérault- France).

DISCUSSION

In the various grape crops, phytoseiid densities were different from year to year and within a same year. This variability in time could be due to different weather conditions between years and to the use of insecticides (i.e., June, 2003) potentially toxic for phytoseiid mites. Some conclusions can be drawn on the influence of agroforestry management on mite abundance and diversity in vine crops.

Sorbus domestica and *P. pinea* co-planted in vine crops or not could provide shelter to phytoseiid mites. However, different phytoseiid mite species were observed on co-planted or monocultures of trees. *Typhlodromus phialatus* was the prevailing species in monoculture tree plot (either *P. pinea* or *S. domestica*), whereas *T. exhilaratus* prevailed in co-planted trees of either species. *Typhlodromus phialatus* was also the prevailing species in uncultivated areas surrounding the experimental plots, whereas *T. exhilaratus* was scarcely found (Barbar et al., 2005). Even if previous studies on the same site showed dispersal of *T. phialatus* and *T. exhilaratus* in the plot (Tixier et al., 2006), it seems that only *T. exhilaratus* could develop both on grape and co-planted trees. Why? Interspecific predation between *T. exhilaratus* and *T. phialatus* could affect the settlement of *T. phialatus* in grape crops. Meszaros et al. (2007) showed in lab experiments that adult females of *T. exhilaratus* attacked larvae and protonymphs of *T. phialatus* and had a greater fecundity than *T. phialatus*. However, these lab data do not explain the dominance of *T. phialatus* in plots with monocultures of trees or in uncultivated areas surrounding grape crops. Thus, other factors seem to be involved. Some authors have assessed toxicities of pesticides on *T. exhilaratus* and *T. phialatus* populations (Castagnoli & Liguori, 1987; Grande & Ingrassia, 1988; Rodrigues et al., 2002). Barbar *et al*. (2007) studied fungicide and insecticide side effects on different populations on *T. phialatus* and *T. exhilaratus* from the same experimental site. They showed a better survival after insecticide (chlorpyriphos-ethyl) of *T. exhilaratus* than of *T. phialatus* (100% mortality at a lower concentration than the recommended rate), suggesting that pesticide application could act as a selective filter allowing the better settlement of *T. exhilaratus* than of *T. phialatus*.

Higher mite densities and a higher frequency of occurrence in time were observed on *P. pinea* than on *S. domestica*, both for *T. phialatus* and *T. exhilaratus* (on monocultural and co-planted trees, respectively). It thus seems that *P. pinea* is a more suitable host plant than *S. domestica* for both phytoseiid species. Phytophagous mites (Tetranychidae, Tenuipalpidae, Eriophyidae) have been observed on the two host plants under study (Barbar, unpubl.). Possibly, different densities of prey species (especially high densities of Tenuipalpidae on *P. pinea*) have a different impact on phytoseiid mite development on *S. domestica* and *P. pinea* (Kreiter et al., 1993; McMurtry & Croft, 1997; Duso & Vettorazzo, 1999). However, more specific studies are needed to test these hypotheses and to draw conclusions on the factors affecting phytoseiid densities on *S. domestica* and *P. pinea*.

In the present study, phytoseiid mites were observed on co-planted *S. domestica* and *P. pinea* and these trees could thus constitute a reservoir for these predators. However, one may wonder if they could constitute a better phytoseiid mite source than rows of grape vine. The densities of phytoseiid mites observed on co-planted *P. pinea* were similar to those observed on cv. Grenache, whereas densities observed on co-planted *S. domestica* were much lower. All factors being equal, a row of *P. pinea* would act as a row of Grenache, providing lower mite densities than a row of cv. Syrah. However, volumes of canopies (numbers of leaves, height of trees, plantation densities) of grape and tree rows are different. To assess a real comparison of mite abundance on vine and tree rows, the determination of the number of leaves per tree and per vinestock would be required.

In the present study, predatory mite abundance in vine crops planted with the two trees was sometimes higher than in the plot with a monoculture of grape. However, these data cannot be generalized, especially in 2003 and 2004. The results obtained in 2003 and 2004 do not allow definitive conclusions because of the particularly dry climatic conditions in 2003 affected densities of phytoseiid mites with a subsequent effect in 2004. In 2005, the populations increased again and during this year a positive effect of agroforestry on mite densities on grape was observed, irrespective of the tree planted. We can thus hypothesize that trees would act as reservoirs for these predators. To determine mite migration between vine and co-planted trees, a molecular typing was carried out. Although more adapted molecular markers have to be applied, the prelimilary results seem to show a dispersal between the populations collected on grape vines and the co-planted trees (Barbar, 2007).

In conclusion, our starting hypothesis was that agroforestry management affects mite density and diversity. This first study concerning impact of agroforestry on grape crop phytoseiid communities showed that: (1) mite density seems to be affected but only in 2005, when mite densities were higher and when impact of external factors was low (low humidity associated with temperatures as high as in 2003), and (2) agroforestry management does not affect phytoseiid mite diversity in grape plots. However, these trends have to be confirmed by further experiments.

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