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Controlling *Scaphoideus titanus*: are pyrethrins and phytoseids compatible?

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ABSTRACT

Mites of the family Phytoseiidae are important generalist predators in European vineyards, where they regulate phytophagous tetranychid and eriophyoid mites. As long as they are not affected by pesticides, they survive, even without prey. Although most fungicides are of low toxicity to Phytoseiidae, some insecticides, notably pyrethroids and pyrethrins, can impact their populations. Today, the application of insecticides within vineyards is reduced thanks to the use of methods such as mating disruption against grapevine moths. However, their use is mandatory in some European and Swiss regions to control the leafhopper *Scaphoideus titanus* to prevent the transmission of Flavescence dorée, a quarantine phytoplasma-born disease. Currently, pyrethrins are the only registered insecticides for managing *S. titanus* in Swiss vineyards. Despite their toxicity to phytoseid mites, their low persistence usually allows for a quick recolonisation of treated vineyards by these predatory mites. However, due to the recent reports of winegrowers, this assumption has come under scrutiny of an increase in spring grape rust mite damage by the eriophyoid mite *Calepitrimerus vitis* in mandatory control areas. To verify the impact of pyrethrins on predatory mites, we monitored 70 Chasselas plots in western Switzerland to compare densities of phytoseids as well as tetranychids and estimated eriophyoid mites' damages in vineyards treated with pyrethrins the previous year with those in untreated plots. Data collected in spring 2023 and 2024 emphasised no significant differences in Phytoseiidae densities between insecticide-treated and untreated plots. Phytoseid species appeared to be randomly distributed between pyrethrin-treated and untreated plots, with *Typhlodromus pyri* being the dominant species. Moreover, the densities of phytophagous mites and grape rust mite damage were low and did not differ between the two treatments. We therefore observed no indications that the application of pyrethrins for the management of Flavescence dorée harms predator mite populations or that these beneficial agents no longer regulate phytophagous mites.

KEYWORDS: *Vitis vinifera*, Grapevine yellows, side effects, IPM, Kampimodromus aberrans, Amblyseius andersoni

INTRODUCTION

Predatory mites of the family of Phytoseiidae are present in most vineyards and effectively regulate phytophagous mite populations in the families of Tetranychidae and Eriophyidae (Duso *et al.,* 2012). Of the many phytoseid species identified on grapevine, *Typhlodromus pyri* Scheuten dominates in central Europe, whereas *Kampimodromus aberrans* Oudemans and *Amblyseius andersoni* Chant are predominant in southern vineyards (*e.g*., Baillod and Venturi, 1980; Duso *et al.,* 2012; Kreiter *et al.,* 2000). These generalist predators are omnivorous and have a diversified diet, including microarthropod prey also pollen, leaf exudates, or fungi (McMurtry & Croft, 1997), and can therefore survive in vineyards, even in the absence of phytophagous mites, as long as they are not disrupted by the application of harmful insecticides or fungicides. Thus, numerous publications targeting winegrowers offer lists of unintended side effects of active ingredients to Phytoseiidae (*e.g*., Dubuis *et al.,* 2025; Kreiter *et al.,* 1997; Sentenac *et al.,* 2002). Although most current fungicides are considered to be of low toxicity to Phytoseiidae, certain families of insecticides, including pyrethroids and pyrethrins, have very marked impacts on their fitness (Duso *et al.,* 2012). However, insecticides are generally rarely applied on a large scale in viticulture, as the main insect pests, particularly grape berry moths, are controlled by biological products (*e.g*., *Bacillus thuringiensis*) or biotechnical methods (*e.g*., mating disruption) that are harmless to predatory mites (Linder *et al.,* 2016). Moreover, the occasional application of harmful insecticides against other minor insect pests (*e.g*., noctuid moths and green leafhoppers) is mostly restricted to small surfaces of a vineyard. This enables predatory mites to recolonise treated plots from surrounding viticultural or wild areas (*e.g*., Boller *et al.,* 1988; Tixier *et al.,* 2006).

Such recolonisation is, however, jeopardised in vineyards affected by Flavescence dorée. This expanding phytoplasma disease is classified as a quarantine organism in the European Union (EFSA, 2020) and Switzerland (Ordonnance sur la santé des végétaux, 2018) and belongs to the elm yellows group (16 Srv). The disease is managed through up to three mandatory insecticide treatments per year, often conducted on a large scale, targeting its main vector, the leafhopper *Scaphoideus titanus* Ball (Chuche & Thiéry, 2014; Gonella *et al.,* 2024). In Europe, the active ingredients currently applied against *S. titanus* include the classes butenolides (*e.g*, flupyradifurone), ketoenols (*e.g*., spirotetramat), neonicotinoids (*e.g*, acetamiprid), natural pyrethrins or pyrethroids (*e.g*, cyhalothrin, cypermethrin, deltamethrin, esfenvalerate, etofenprox and tau-fluvalinate) (Gonella *et al.,* 2024). Whereas butenolides, ketoenols and neonicotinoids can be classified as being of low to moderate toxicity to predatory mites, pyrethroids and natural pyrethrins are considered to be harmful (*e.g*., Duso *et al.,* 2012; Duso *et al.,* 2014; Rodrigues, 2012). Since 2019, only pyrethrin-based commercial products have been authorised in the mandatory control of *S. titanus* in Swiss organic, integrated and conventional vineyards. Although the impact of natural pyrethrins on Phytoseiidae is not negligible, their low persistence often enables rapid recolonisation of treated grapevines (Constant & Lernould, 2014; Duso, 2012; Duso *et al.,* 2022; Gusberti *et al.,* 2008; Linder *et al.,* 2008; Mori *et al.,* 2004; Pozzebon & Duso, 2010). However, this ability to recolonise treated plots has recently been questioned by Swiss winegrowers following a reported increase in damage caused by the grape rust mite *Calepitrimerus vitis* Nalepa in areas treated against *S. titanus.* Usually, this phytophagous mite is well regulated by *T. pyri*, *A. andersoni* and *K. aberrans* in Europe (Duso *et al.,* 2012) as well as Switzerland. Aiming to respond to these concerns, we set up a survey to assess predatory and phytophagous mite populations in pyrethrin-treated and untreated vineyards in western Switzerland over two years.

MATERIALS AND METHODS

To compare phytophagous and predatory mite populations, we sampled plots within and outside of mandatory control areas in a paired design at a total of five different locations (*e.g*., Bourg-en-Lavaux 1, Bourg-en-Lavaux 2, Chardonne, Dardagny, Fully) situated in three different cantons (*i.e*., Genève, Valais and Vaud) of western Switzerland (Table 1). To minimise variations in mite population densities due to the leaf structure (Schmidt-Jeffries, 2014), we focused our sampling on Chasselas plots, the main white cultivar grown in western Switzerland. At each location, we randomly selected five plots within a maximum radius of 500 m within the mandatory control area, as well as in its direct untreated neighbouring area with a maximum distance of 300 m, resulting in a total of 10 plots per site. Vineyards within the mandatory control areas were treated once or twice at an interval of 12–14 days with natural pyrethrins (Parexan N® at 80 g a.i./ha or Pyrethrum FS® at 64 g a.i./ha) at the appearance of the third nymphal instar of *S. titanus* in the year preceding our sampling. Except for these mandatory treatments usually conducted around June, no other insecticides or acaricides were applied in all 70 plots, and fungicide treatments were carried out with active ingredients classified as having low toxicity to phytoseids (Dubuis *et al.,* 2025).

We sampled four different locations in early spring of 2023 and three sites in 2024, resulting in 70 assessed plots of cv. Chasselas over two years. In each plot, we randomly selected 25 individual grapevines per plot and recorded whether they showed any symptoms of grape rust mite infestation, such as stunted shoots, deformed growth or leaf distortion. We also collected a single leaf on each of these grapevines from the base of shoots close to the old wood, as they host a larger number of overwintering predatory mites and are consequently first colonised. In the laboratory, we counted the number of tetranychid and phytoseid mites on each collected Chasselas leaf under a binocular magnifying glass. In addition, phytoseid mites from the plots of each canton were pooled, and 41–219 phytoseids per canton were randomly extracted and identified at the species level by mounting them in hollow slides following the previously described procedure (Baillod & Venturi, 1980; Kreiter & De La Bourdonnaye, 1993; Karg, 1993). To fit the assumptions of generalised linear models (GLM), negative binomial models were fitted

TABLE 1. Locations, treatments and sampling dates.

Year	Sites & Cantons (Latitude, longitude [in decimal degrees])	Mandatory treatments since	Number of mandatory pyrethrin applications in the previous year	Sampling dates
2023	Dardagny; Genève (N46.19°, E5.98°)	2022	2	08.05.2023
	Bourg-en-Lavaux 1; Vaud (N46.49°, E6.27°)	2021	2	09.05.2023
	Bourg-en-Lavaux 2 ; Vaud (N46.50°, E6.73°)	2021	2	09.05.2023
	Chardonne; Vaud (N46.47°, E6.81°)	2018	1	09.05.2023
2024	Dardagny; Genève (N46.19°, E5.98°)	2022	1	24.04.2024
	Bourg-en-Lavaux 1 ; Vaud (N46.49°, E6.27°)	2021	2	01.05.2024
	Fully; Valais (N46.13°, E7.10°)	2023	2	01.05.2024

on Phytoseids count data to control for overdispersion. For the overall analysis, "Site" was included as a random factor to account for pseudo-replication. A *p*-value of 0.05 was considered statistically significant, and all statistical analyses were conducted using RStudio 2025.05.1 (R Core Team, 2025).

RESULTS

Over the two years, no grape rust mite symptoms were observed in any of the 70 monitored plots. In 2023, the tetranychid mite *Panonychus ulmi* (Koch) was observed in only two plots at Dardagny, one inside and the other outside of the mandatory control area, but both at a very low density of 0.14 ± 0.28 motile form per leaf (mean value ± SD). In 2024, *P. ulmi* was only observed in the Valais, where 80 % of the plots treated or untreated with pyrethrins in the previous season were infested by small populations of 0.28 ± 0.35 motile forms per leaf.

Regarding phytoseid mites, the mean predatory mite density tended to be slightly higher in treated compared to untreated plots, with 1.35 ± 1.2 versus 0.92 ± 1.43 individuals per leaf ($\chi^2 = 3.09$, df = 1, $p = 0.07$). Further analyses within a site for the same year showed that there were mostly no significant differences between pyrethrin-treated plots and neighbouring control plots, with the exception of Dardagny in 2023 and Fully in 2024 (Figure 1). In both, the density of phytoseids was significantly higher in plots treated twice with pyrethrins

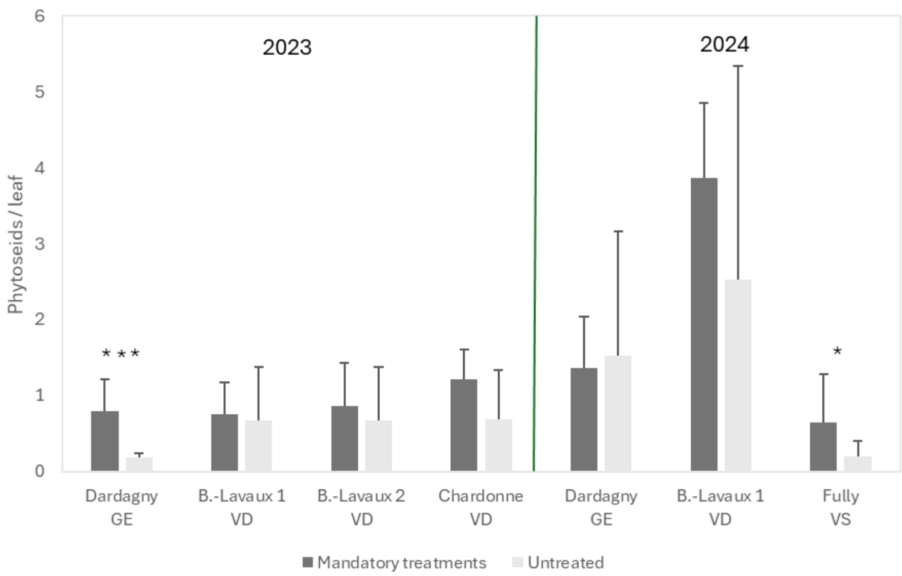

FIGURE 1. Average densities of predatory mites per leaf in the five study locations in 2023 and 2024, treated or untreated with pyrethrins against *S. titanus* in the previous year. n = 2 × 5 plots per site. Error bars represent the standard error, and * indicates statistically significant differences between the two treatments at a location within a year (Likelihood ratio test (χ^2), $p < 0.05$).

in the previous year than in adjacent untreated vineyards (Dardagny 2023: χ^2 = 14.08, df = 1, p = 0.0001; Fully 2024: χ^2 = 5.13, df = 1, p = 0.023). Overall, the average predatory mite densities varied between 0.18–1.22 individuals per leaf in 2023 and 0.20–3.86 individuals/leaf in 2024.

The identified phytoseid community consisted of *T. pyri*, *A. andersoni*, *K. aberrans*, *Paraseiulus talbii* (Athias-Henriot) and *Euseius* sp., and the five species were randomly distributed between the pyrethrin-treated and untreated plots. *Typhlodromus pyri* was the dominant phytoseid species at all sites (Figure 2), accounting for almost 98 % of the identified specimens in the canton of Vaud. In Geneva, *T. pyri* was associated with *A. andersoni*, with the latter accounting for 28 % of the identified individuals. In the canton of Valais, four phytoseid species were present, but *T. pyri*, *K. aberrans* and *A. andersoni* were the dominant species, at 76 %, 15 % and 7 %, respectively. Although *P. talbii* was found in Vaud and *Euseius* sp. in both Vaud and Valais, both species currently seem to be a minor part of the predatory mite community in western Switzerland.

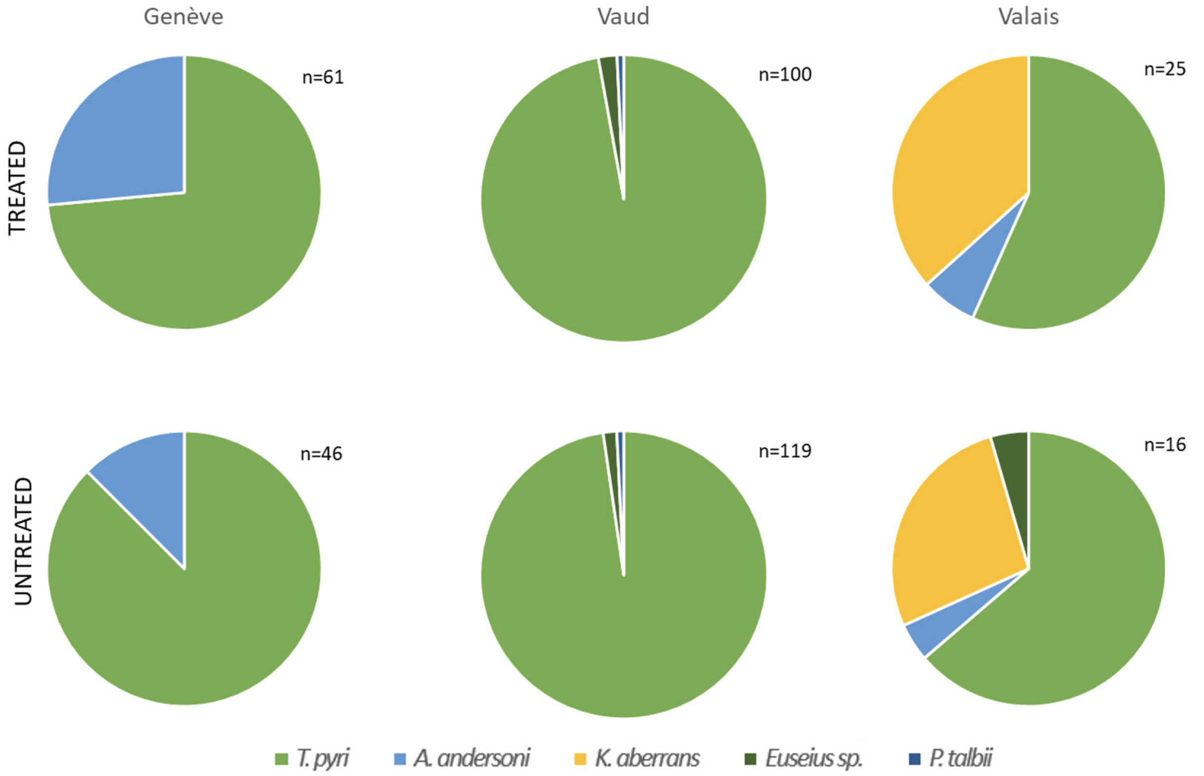

FIGURE 2. Species of phytoseids identified in the spring of 2023 and 2024 in the untreated and pyrethrin-treated vineyards of the three cantons sampled in western Switzerland.

DISCUSSION

Apart from two locations, we observed no significant differences in phytoseid densities between vineyards treated with pyrethrins in the previous year and untreated neighbouring control plots in the following spring in western Switzerland. The predatory mite population was higher in the pyrethrin-treated plots than in the untreated control at these particular sites. Similarly, the density of phytoseids was slightly higher in the vineyards with mandatory insecticide control compared to their neighbouring control plots in four of the other five studied locations. Previous studies (Constant & Lernould, 2014; Duso, 2012; Duso *et al.,* 2022; Gusberti *et al.,* 2008; Linder *et al.,* 2008; Mori *et al.,* 2004; Pozzebon & Duso, 2010) have shown that populations of phytoseids recover quickly from the impact of natural pyrethrins, even though their application can sometimes have marked short-term effects on some phytoseid species (*e.g.*, *T. pyri*, *A. andersoni* and *K. aberrans*). Notably, the maximum registered doses of pyrethrins against *S. titanus* in Switzerland are nearly double that in France or Italy, with 58–76 g a.i./ha compared to 27.9–44 g a.i./ha, respectively (https://www.psm.admin.ch; https://ephy.anses.fr; https://www.sian.it). Despite this relatively large difference in dosage, our findings did not indicate any significant declines in the predatory mite populations from one season to the next.

In addition to pyrethrin applications, predatory mite densities are affected by many additional factors beyond the scope of this survey. In particular, the availability of alternative food sources (*e.g.*, Pozzebon *et al.,* 2010; Pozzebon *et al.,* 2014), the influence of repeated fungicide treatments (*e.g.*, Prischmann *et al.,* 2005), grape cultivar (Duso *et al.,* 2012; Schmidt-Jeffries, 2014), the understory, the immediate environment and their recolonisation capacity influence predatory might populations (Tabary *et al.,* 2024). It also cannot be ruled out that, locally, the recent increase in grape rust mite symptoms may be partly due to low predator densities caused by a succession of hot and dry summers (Linder, 2005). These conditions are generally favourable for the development of eriophyids and disadvantageous to predatory mites, particularly *T. pyri,* the main species identified in our survey (Duso *et al.,* 2012). Furthermore, these population increases in *C. vitis* are probably not exclusively linked to favourable meteorological conditions, as phytosanitary practices, management methods and varietal susceptibility may also play a role (Linder *et al.,* 2016). As such, leaves of Chasselas are characterised by zero to low hair density (Dupraz & Spring, 2010), and this characteristic is, in general, moderately favourable for the development of grape rust mites as well as predatory mites, particularly *T. pyri* and *K. aberrans*, which tend to favour pubescent grape cultivars (Duso *et al.,* 2012; Schmidt-Jeffries, 2014). Thus, important rust mite symptoms have been observed on this grape variety, and Chasselas is overall considered to be rather sensitive in western Switzerland (Guignard *et al.,* 1970; Baillod & Guignard, 1986; Linder, 2005). Despite this, we were unable to detect any symptoms caused by grape rust mites in the 70 monitored Chasselas plots over the two years, and even tetranychid mites were rare. Additional studies on other grape cultivars with other ampelographic characteristics might supplement these initial findings and thus emphasise their generality.

This survey also showed that predatory mites were present in all sampled locations at varying densities depending on the region and plot. Considering the complex of predatory mite species, *T. pyri* is still the dominant species in the vineyards of western Switzerland. As previously reported, *A. andersoni* is also present in the vineyards of Geneva and Valais, whereas this species is not observed in the canton of Vaud (Baillod & Venturi, 1980; Linder *et al.,* 2005; Linder *et al.,* 2008). Finally, the more southerly species, *K. aberrans,* was determined for the first time in Valais. This species is more frequent and abundant south of the Alps, although there have been sporadic reports in Vaud (Baillod & Venturi, 1980; Linder *et al.,* 2008). Overall, our study reveals no major differences in the sensitivity of the determined phytoseid species to pyrethrins.

CONCLUSION

Controlling *S. titanus*, the main vector of Flavescence dorée, with pyrethrins is currently the only direct control measure available in Swiss viticulture, as in most organic vineyards in Europe. Our data indicate that predatory mite communities do not appear to be negatively affected by pyrethrins under the conditions of our study. This makes their use compatible with IPM and organic farming without jeopardising the biological control of phytophagous mites. Therefore, the recent development of sometimes severe grape rust mite symptoms does not seem to be directly linked to a decline in predatory mites but rather to multiple extrinsic factors that winegrowers can hardly influence. Nonetheless, it is important to regularly assess how predatory mite communities adapt and evolve to changing management practices and to a warming climate to conserve their ecosystem service of biological pest control in food production.

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