Department of Agriculture and Food

Australian Government
Grape and Wine Research and Development Corporation

Building a management package for six-spotted mite in vineyards.



Six-spotted mite caused premature leaf senescence in Shiraz grapes, compared to Merlot to the left and Chardonnay in the background – May 2008.

FINAL REPORT to

GRAPE AND WINE RESEARCH & DEVELOPMENT CORPORATION

Project Number: **RD 06/04-1**

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Research Organisation: **DEPARTMENT OF AGRICULTURE AND FOOD WESTERN AUSTRALIA**

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SUMMARY

Six-spotted mite is a comparatively new mite species recorded in Western Australian vineyards. Infestations of the mite result in premature loss of leaf function in late summer/autumn. To date the mite is known to occur in vineyards in Western Australia only, though it does occur in avocado orchards in eastern Australia. Since its discovery in vineyards in WA in 2006 the mite has been confirmed to be present in the Margaret River and Manjimup/Pemberton regions. This project sought to clarify its distribution in Western Australia, to quantify its pest status in vineyards and to assess whether introduced predatory mites could help manage it.

Six-spotted mite was found in 75% of vineyards in the southern Margaret River Region (13 vineyards surveyed) and 54% vineyards in the Manjimup/Pemberton region (26 vineyards surveyed). The level of mite infestation varied from finding the mite sporadically to high levels of infestation resulting in premature loss of leaf function. Six-spotted mite was not found in the northern Margaret River region (5 vineyards surveyed).

Because of the vagaries of infestations of six-spotted mite, studies to quantify the pest status of the mite could not be completed. Likewise, assessing the effect of introduced predatory mites in one vineyard in season 2006/07 on the management of six-spotted mite has been compromised by the sudden unexplained disappearance of the mite from release sites the following season. At three vineyard study sites where predatory mites were released in season 2007/08, an increase in the abundance of natural control agents was assumed to be the cause for a crash in the population of six-spotted mite. The main naturally occurring predators involved included an unidentified species of predatory mite, six-spotted thrips and stethorus beetles. The predators failed to prevent severe leaf damage.

This report reviews the work undertaken and makes recommendations regarding further studies on the mite in vineyards.

INTRODUCTION

Six-spotted mite (*Eotetranychus sexmaculatus* (Riley)) was first recorded in Western Australia in 1986 from avocado seedlings imported to Western Australia from the eastern states. The mite was not seen again in Western Australia until damage to grapevines in the form of premature leaf fall was reported in 2006. At that time, the mite was recorded only from the southern Margaret River winegrape region and an avocado orchard near Pemberton.

Damage to grapevines in the form of premature leaf bronzing was restricted to two vineyards but a further seven vineyards in the same locality were found to be infested with the mite but at very low levels. There did not appear to be any particular reason for the mite causing problems in only two of the nine infested vineyards. In the avocado orchard, the mites were present at very low levels also, not causing any damage.

With the occurrence of significant damage to the canopy of grapevines by this new pest, a literature search was undertaken as well as preliminary field investigations on the biology, distribution and management of six-spotted mite in WA. The results have been published in a farmnote (Fisher and Learmonth, 2006). From the field trials on a range of miticides, a request for a minor use permit from the Australian Pesticides and Veterinary Medicines Authority resulted in permit PER9680 being granted.

After these preliminary actions, the continuing occurrence of premature loss of leaf function in infested vineyards prompted the need for further investigations. The studies undertaken which are reported here were on surveys to clarify the distribution of the mite, to quantify its pest status and to determine whether commercially available predatory mites have an impact in reducing the abundance of six-spotted mite.

METHODS

Sampling for six-spotted mite

Studies reported here involved assessments of the presence, abundance and leaf damage associated with six-spotted mite.

The presence of six-spotted mite in vineyards was based initially on leaves showing characteristic discolouration along leaf veins as reported by Fisher & Learmonth (2006). The presence of mites was confirmed either in the field using a 10 times hand lens, or in the laboratory using a dissecting microscope. If mites were not present, eggs with apical spines or presence of cast skins of stethorus beetle predators usually associated with six-spotted mite were used to confirm whether a particular vineyard was infested.

The abundance of six-spotted mite was assessed on a sample size usually of 25 leaves per plot. If a double row of vines was involved in a treatment, leaves were collected from alternate sides down the row. The abundance of mites on leaves was assessed using a dissecting microscope and examining three 25mm diameter fields of view per leaf. The fields included the "claw" of the leaf, that is, where the leaf veins meet the petiole. This area of leaves is the most likely area to be infested first by six-spotted mite. The other two fields per leaf included some portion of the main veins across the lamina of the leaf where mites also tend to accumulate. The abundance of mites was based on a score system: 0 = none; L = 1 to 5 mites/field; M = 6 to 25 mites/field; H = >25 mites/field.

Damage to leaves by six-spotted mite was also rated based upon the proportion of a leaf that was discoloured by the mite's feeding. The level of damage was also assessed using a score system: 0 = none; 1 = minor; 2 = moderate; 3 = severe.

Distribution of six-spotted mite in Western Australia

The distribution of six-spotted mite in Western Australia was investigated by advising WA vignerons of the current distribution of the mite through articles in the Department of Agriculture and Food Western Australia's (DAFWA) extension publication *Wine Industry Newsletter*. Also, vignerons were referred to the farmnote on six-spotted mite with photographs of the symptoms on infested leaves. This was complemented by on-ground surveys of selected vineyards in the Margaret River and Manjimup/Pemberton regions.

For the field surveys, the number of vineyards that could be visited was restricted due to time and cost constraints. Some priority was given to examining vineyards in the southern end of the Margaret River region because this was where the mite was first recorded in WA vineyards. Also, those vineyards in this area that had previously been inspected and not found to be infested with the mite in 2006 were revisited in 2008. Some vineyards in the northern and central areas of the Margaret River wine region were also included. In the Manjimup/Pemberton region, where the mite was known to occur in avocado orchards, a selection of vineyards across the region was surveyed for the mite.

The surveys within vineyards included observations on each variety. The number of rows examined per variety was related to the proportion of the vineyard occupied by that variety. Complete lengths of two adjacent rows were the minimum examined for each variety and depending on the size of the block of that variety, more double rows were examined. Any leaves suspected of having characteristic six-spotted mite symptoms were examined in the field with a ten times hand lens. If there was any uncertainty as to whether six-spotted mite was present, the leaves were returned to the laboratory for examination using a dissecting microscope. Where six-spotted mite was confirmed to be present, any associated natural enemies thought to be feeding on six-spotted mite were collected for subsequent identification. From results of the monitoring, infested vineyards were further classified into an infestation level category – see below.

Vignerons were advised of the results of the survey of their property.

Pest status of six-spotted mite

In the original six-spotted mite infested vineyard in the southern Margaret River region, monitoring of vines in early summer of the 2006/07 season revealed that areas which were very

heavily infested in the 2005/06 season had become virtually mite free. While some of the more heavily infested areas had been sprayed with miticides, other moderately infested areas in the autumn of 2006 were not sprayed. The explanation for the disappearance of the mite the following season in these latter areas was not clear.

By March 2007, other blocks in the same vineyard that had previously been only moderately infested, had become infested at levels where an edge effect of moderate to severe leaf damage was present (see Figs. 1 a and b below). These two adjacent blocks of Sauvignon Blanc and Merlot were selected for the study on quantifying the pest status of six-spotted mite.

Because of the threat posed by six-spotted mite to vines on the edges of these blocks, both areas of heavier infestation there were sprayed after vintage by the vigneron on 5 April 2007. Monitoring of the sprayed and adjacent areas was undertaken. The adjacent unsprayed areas of these two varieties were used for the study on the pest status of six-spotted mite.

Equal sized paired portions of blocks of the grape varieties Sauvignon Blanc and Merlot were either unsprayed or sprayed with a miticide. The miticide Talstar 100EC was applied at a rate of 40ml/100L and 500L/ha on 19 April 2007 using a vehicle mounted sprayer with hydraulic nozzles mounted on a two arm sprayer. The miticide was applied to each side of one row of vines to be used for monitoring while also spraying one side of the canopy of the adjacent row on each side of the monitoring row. Spraying one side of the adjacent rows provided a treated buffer for the sprayed monitoring row. Rows equidistant from adjacent sprayed plots acted as untreated controls. Four such paired plots in each variety were included in the study.

The abundance of mites was assessed in sprayed and unsprayed plots in each variety on 23 April 2007 (4 days after spraying), 14 May 2007 (25 days after spraying) and in the following season on 14 November 2007 and 6 February 2008.

The role of inundative releases of predatory mites in managing six-spotted mite

Mass reared predatory mites with two-spotted mite as the prey species, were available from two companies – *Galendromus* (formerly *Typhlodromus*) *occidentalis* (GO) was available from South Australia and *Phytoseiulus persimilis* (PP) was available from Queensland. The latter culture of predatory mites included an unidentified contaminant species of predatory mite that has been shown to be capable of feeding on six-spotted mite (Learmonth et al 2007).

These predatory mites were released into two separate areas in each of three vineyards infested with six-spotted mite in the Manjimup/Pemberton region. Mites were received on bean leaves. The consignment was divided into a number of equal portions depending on the number of vine panels in the release plots. The bean leaves were placed into open weave bags from which the predatory mites could walk onto vine leaves when tied onto the canopy. Release plots for the predatory mites were two adjacent rows of vines with the length of the rows varying form 48m to 72m (8 to 12 panels). One bag of bean leaves was tied onto the vine canopy per alternate panel and alternate side of the release double row. Subsequent releases were on the opposite panels along the same rows. A similar sized area of vines between the release areas acted as the non-release area for comparison.

Releases of GO were made in blocks of Chardonnay in Vineyards #1 and #2 on 27 February and 13 March 2008, and a single release of PP was made in the same vineyards on 13/14 March 2008. Releases of GO were made in a block of Shiraz in Vineyard #3 on 4 and 10 April 2008, while a single release only of PP was made in this vineyard on 10 April 2008.

Samples of vine leaves were collected from each of the three areas in each vineyard where predatory mite releases were made. Leaves were assessed for six-spotted mite, released predatory mites and any other natural control agents using a dissecting microscope.

Specimens of predatory mites from the cultures as received and predatory mites from field sites were retained to confirm their identity.

RESULTS

Distribution of six-spotted mite in Western Australia

No reports were received from vignerons via articles in the DAFWA *Wine Industry Newsletter* as to whether six-spotted mite was suspected of being present. This is probably a reflection of the time of season that six-spotted mite is usually most abundant in vineyards – after veraison and near vintage. At this time, leaf discolouration is a normal event and given seasonal variation in the timing of vintage, vignerons may not always be aware of earlier discolouration being caused by a pest such as six-spotted mite. This situation needs to be overcome by an increased level of publicity that vineyards may be infested with this new species of mite. Because of the very characteristic discolouration of infested leaves, the detection of even low level six-spotted mite infestations is possible (see Fisher & Learmonth, 2006).

The overall results of the on-ground surveys in the Margaret River and Manjimup/Pemberton regions are given in Table 1. While only 5 vineyards in the northern and central areas of Margaret River were included in the survey, the mite has not been found there. More vineyards would need to be examined to confirm that the mite is not present in this region. Of the thirteen vineyards that have now been surveyed in the southern area of Margaret River, 75% were infested. These are all within about 15km of the original infested vineyard.

Table 1. Results of vineyard surveys to detect the presence of six-spotted mite (SSM) in south west Western Australia.

Region	Vineyards surveyed	Vineyards with SSM	% vineyards with SSM
north & central Margaret River	5	0	0
south Margaret River	13	9	75
Manjimup/Pemberton	26	14	54
TOTAL	**44**	**23**	**52**

Just over half the vineyards in the Manjimup/Pemberton region examined were found to be infested with six-spotted mite. Most of these were in the southern part of the region, close to areas of avocado production. With two notable exceptions, avocado orchardists were not aware of the presence of six-spotted mite. This is probably related to the existence of a balance between a range of natural enemies yet to be identified on this evergreen host plant.

An indication of the severity of the infestation on the vineyards where six-spotted mite was confirmed to be present is given in Table 2. The level of infestation ranges from LOW = detecting six-spotted mite was difficult because only a few leaves with characteristic six-spotted mite feeding symptoms in just a few areas in a vineyard were evident; MEDIUM = the mite is easily found on damaged leaves in more than half of the blocks across the vineyard, but significant premature leaf function loss is not evident; HIGH = at least one block of vines had a heavy infestation of six-spotted mite with associated high levels of premature leaf function loss where the ability of the vines to mature the crop would have been compromised. The last two categories would require monitoring by vignerons the following season to be aware of the possibility of a mite outbreak.

Table 2. The level of infestation of six-spotted mite in infested vineyards in south west Western Australia in the 2007/08 season – see text for an explanation of the levels.

Six-spotted mite	**Region**	
infestation level	**south Margaret River**	**Manjimup/Pemberton**
LOW	7	7
MEDIUM	1	4
HIGH	1	3

Pest status of six-spotted mite

The infestation level of mites in the Sauvignon and Merlot blocks at the southern Margaret River vineyard on 13 March 2007 are given in Figs. 1 a and b. These levels represent the situation prior to the application of miticide in the more heavily infested edges of these blocks.

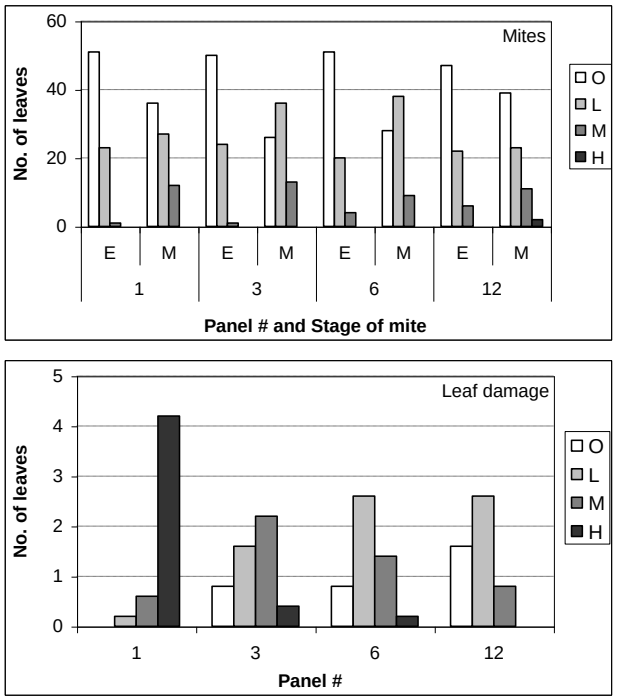


Fig 1 a. The number of vine leaves (multiplied by 3 fields of view per leaf using a microscope for mite abundance) infested with six-spotted mite at a range of abundance and damage levels (see text for explanations of the mite infestation and leaf damage levels) in panels of increasing distance from the edge of the block of Sauvignon Blanc on 13 March 2007. E = eggs; M = mites.

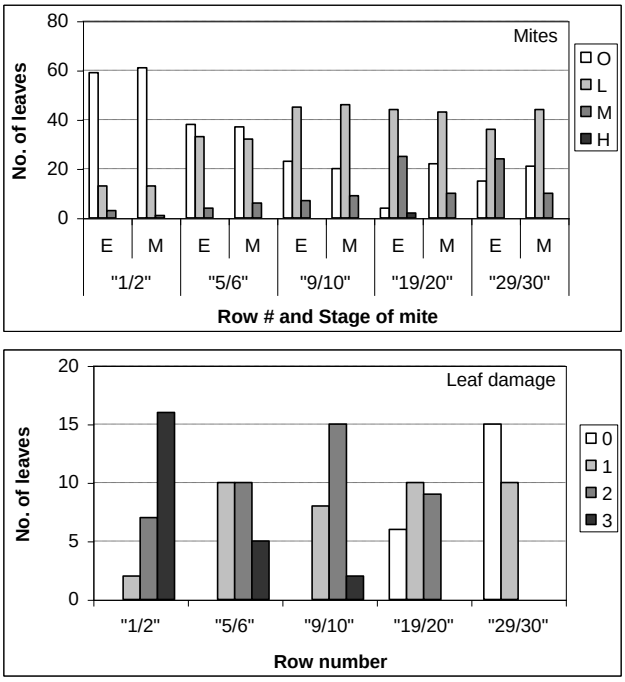


Fig 1 b. The number of vine leaves (multiplied by 3 fields of view per leaf using a microscope for mite abundance) infested with six-spotted mite at a range of abundance and damage levels (see text for explanations of the mite infestation and leaf damage levels) in rows of increasing distance from the edge of the block of Merlot on 13 March 2007. E = eggs; M = mites.

The effect of the miticide application and the mite abundance in adjacent unsprayed areas within these blocks are given in Fig. 2. The application of miticide successfully controlled six-

spotted mite. The unsprayed areas within the blocks of Sauvignon Blanc and Merlot were selected for the study on quantifying the pest status of six-spotted mite.

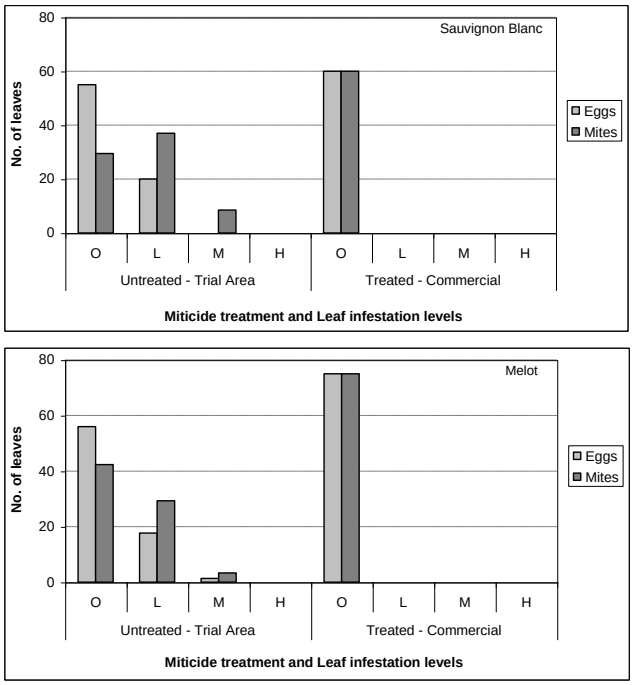


Fig. 2. The number of vine leaves (multiplied by 3 fields of view per leaf using a microscope for mite abundance) in parts of blocks of Sauvignon Blanc and Merlot infested with six-spotted mite at a range of abundance levels (see text for explanations of the mite infestation levels) on 11 April 2007 in areas either untreated or sprayed with a miticide I on 4 & 5 April 2007.

The results of spraying miticide on 19 April 2007 within the previously unsprayed areas of the blocks of Sauvignon Blanc and Merlot expressed as an average over the four paired plots within each variety are given in Figs. 3 and 4 for the sampling on 23 April and 14 May 2007, respectively.

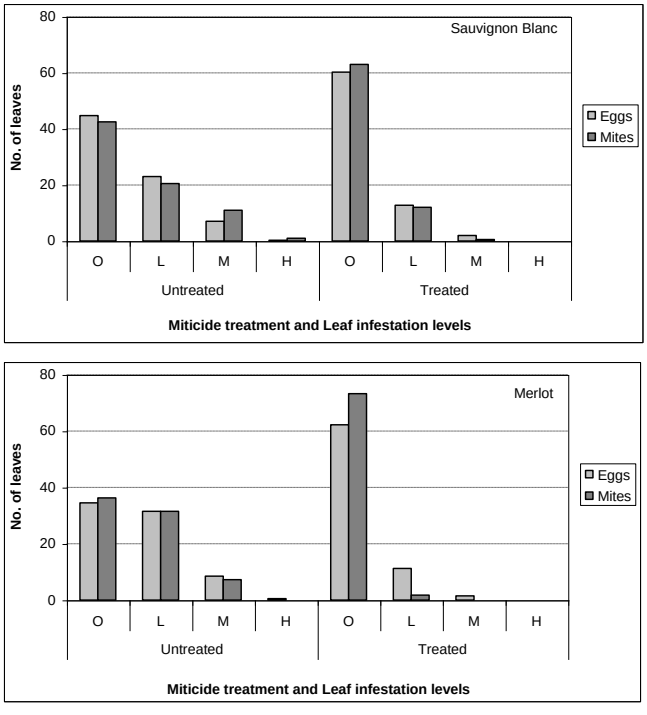


Fig. 3. The average number of grapevine leaves (multiplied by 3 fields of view per leaf using a microscope for mite abundance) in blocks of Sauvignon Blanc and Merlot infested with six-spotted mite at a range of infestation levels (see text for description) in plots that were either untreated or sprayed with miticide on 19 April 2007 and mites scored on 23 April 2007.

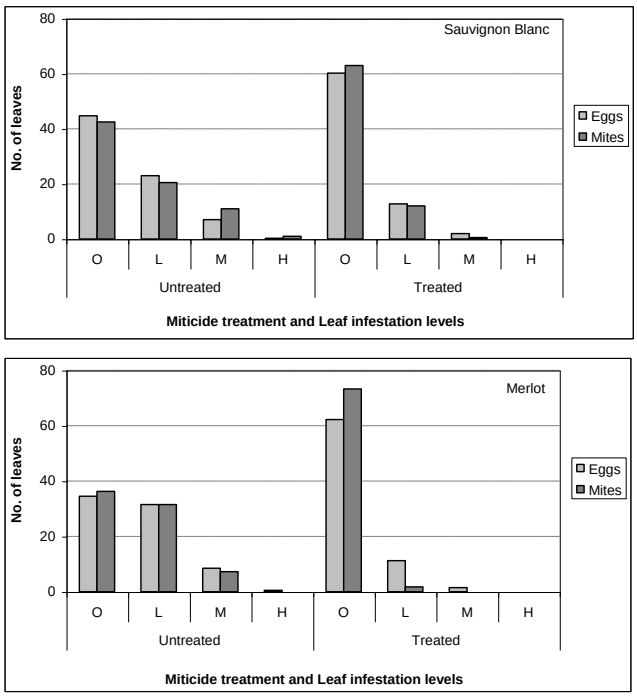


Fig. 4. The average number of grapevine leaves (multiplied by 3 fields of view per leaf using a microscope for mite abundance) in blocks of Sauvignon Blanc and Merlot infested with six-spotted mite at a range of infestation levels (see text for description) in plots that were either untreated or sprayed with miticide on 19 April 2007 and mites scored on 14 May 2007.

The spraying was not completely successful in eliminating six-spotted mite from rows within the two varieties, but did reduce the abundance over the untreated area. This difference in abundance levels gave the desired outcome to establish different infestation levels which it was planned would lead to variations in mite abundance the following season.

The paired areas of untreated and miticide treated vines in the blocks of Sauvignon Blanc and Merlot sampled on 14 November 2007 and 6 February 2008 showed that the mite was absent from all areas. Very low numbers of mites were found in autumn 2008. With this result, no further studies on assessing the effect of six-spotted mite on grape quality or yield in this vineyard were warranted.

The role of predatory mites in managing six-spotted mite

The abundance of six-spotted mite eggs and motiles (all mites after egg hatch), mite damage to leaves and the abundance of predatory mites and predatory insects in each of the three vineyards where predatory mite releases were made are given in Figs. 5, 6, 7.

Selection of the three vineyards for the release of predatory mites was based on the presence of severe mite damage that identified the vineyards as being infested with this mite. This is reflected in the presence of a suite of natural enemies including predatory mites at the time of release of the commercially available predatory mites.

In all three vineyards, the abundance of six-spotted mite declined over the monitoring period (see Figs 5a, 6a, 7a). In Vineyards #1 and #2, six-spotted mite was virtually absent at the end of the monitoring period in mid April. Given that this was before the usual time of natural leaf senescence for the region, the reduction in mite abundance was ascribed to the natural control agents found on the leaves. In Vineyard #3, low numbers of six-spotted mite remained to late April. Over the same time, the level of leaf damage either remained about the same as the first sampling time, or increased slightly for all three vineyards (see Figs. 5a, 6a, 7a).

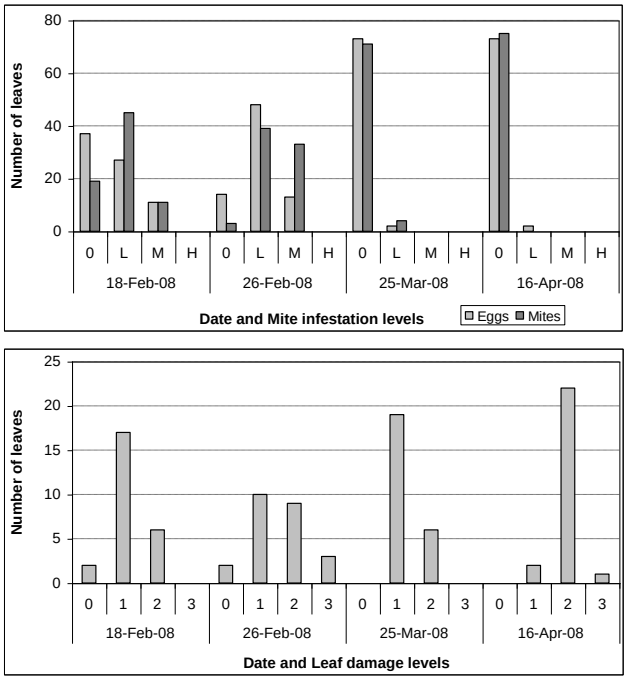
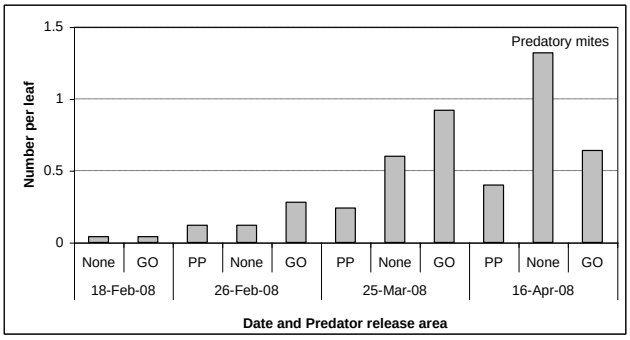
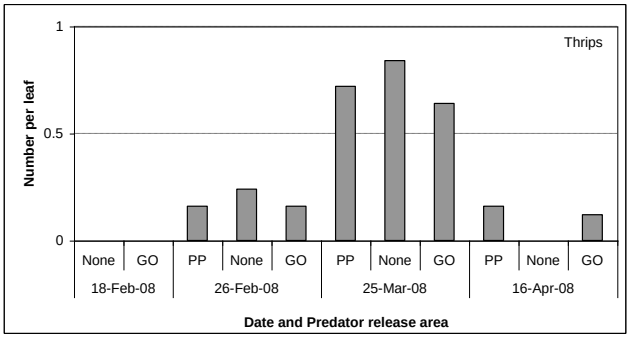


Fig. 5a. The number of grapevine leaves (multiplied by 3 fields of view per leaf using a microscope for mite abundance) infested with six-spotted mite at a range of infestation levels and the number of leaves with a range of damage levels (see text for explanations) in Vineyard #1 where predatory mites were released on 27 February 2008 (GO), 13March 2008 (GO and PP) and 14 March 2008 (PP).





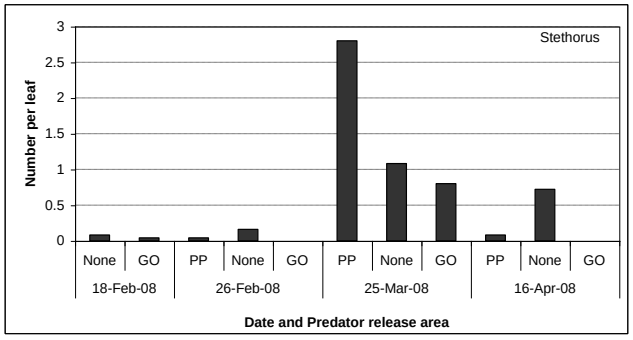


Fig. 5b. The average number of predatory mites, predatory thrips and stethorus beetles on vine leaves in Vineyard #1 infested with six-potted mite.

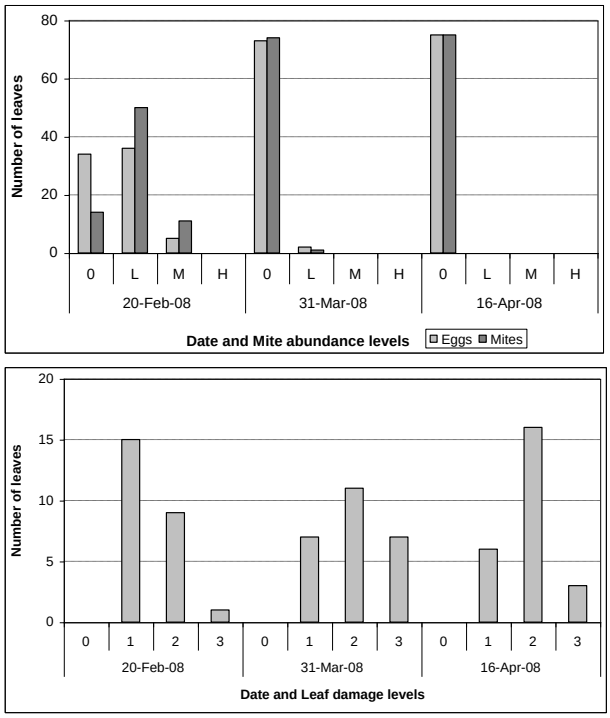


Fig. 6 a. The number of grapevine leaves (multiplied by 3 fields of view per leaf using a microscope for mite abundance) infested with six-spotted mite at a range of infestation levels and the number of leaves with a range of damage levels (see text for explanations) in Vineyard #2 where predatory mites were released on 27 February 2008 (GO), 13March 2008 (GO and PP) and 14 March 2008 (PP).

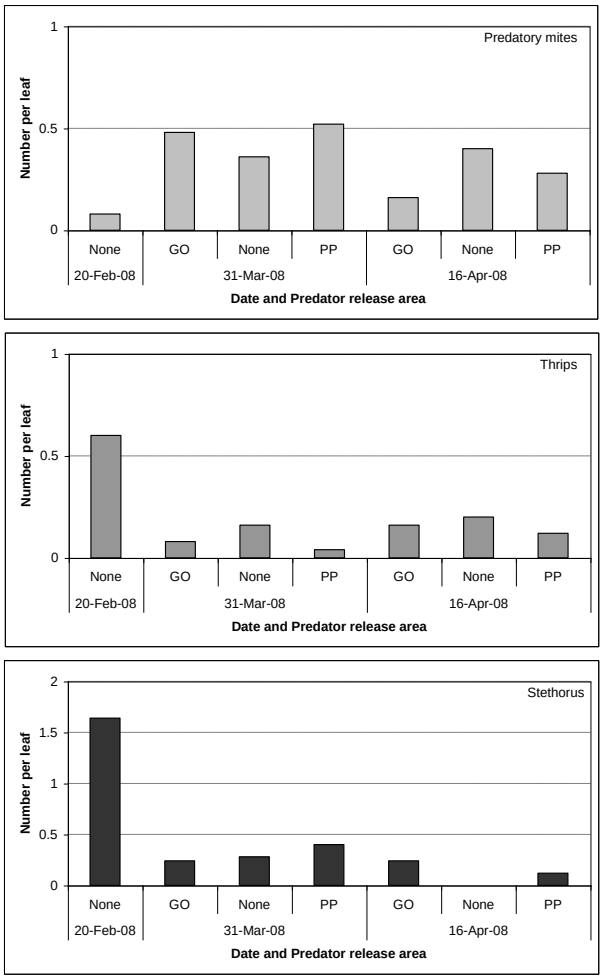


Fig. 6 b. The average number of predatory mites, predatory thrips and stethorus beetles on vine leaves in Vineyard #2 infested with six-potted mite.

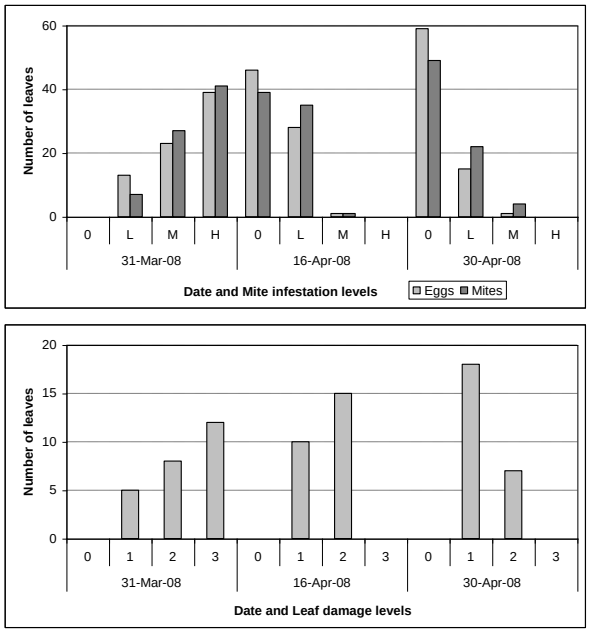


Fig. 7 a. The number of grapevine leaves (multiplied by 3 fields of view per leaf using a microscope for mite abundance) infested with six-spotted mite at a range of infestation levels and the number of leaves with a range of damage levels (see text for explanations) in Vineyard #3 where predatory mites were released on 27 February 2008 (GO), 13March 2008 (GO and PP) and 14 March 2008 (PP).

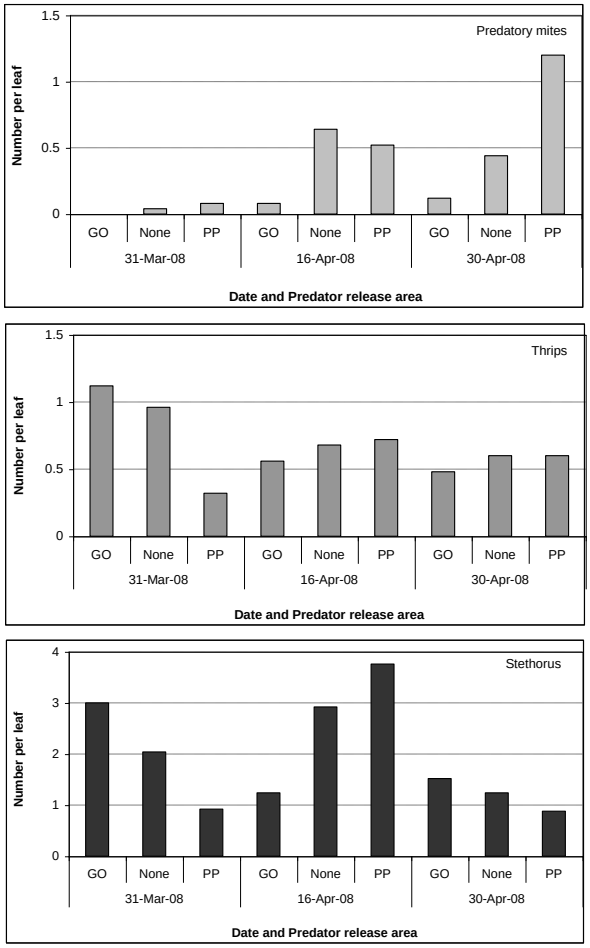


Fig. 7 b. The average number of predatory mites, predatory thrips and stethorus beetles on vine leaves in Vineyard #3 infested with six-potted mite.

The three groups of natural enemies found on the leaves were predatory mites, predatory thrips and the predatory beetle stethorus (see Figs. 5b, 6b, 7b). The predatory thrips was most likely

six-spotted thrips, *Scolothrips sexmaculatus*. In terms of numbers per leaf, the predatory stethorus beetles were most abundant, but their numbers appeared to fluctuate more compared to the abundance of the other two. Predatory mites and thrips were present in roughly equal numbers per leaf and their presence was more consistent over the sampling period.

On any one sampling occasion, there were only slight differences in the abundance of predatory mites across the three areas in the predatory mite release studies - the two release areas and the non-release rows. This suggests that the release of commercially available predatory mites had little or no effect on mite numbers in these vineyards and that most of the predatory mites found on the leaves were the naturally occurring species. Collections of predatory mites remain to be examined by a taxonomist to clarify this situation.

It is proposed that all release sites be monitored in the 2008/09 season for possible effects of the predatory mite releases.

DISCUSSION

Currently in Australia six-spotted mite has been recorded in Queensland, New South Wales and South Australia on avocados and in nurseries, and in Western Australia on avocados and grapevines and some ornamental plants and weeds. So far, WA remains the only state where the mite has been recorded from grapevines. This mite has been recorded to be present occasionally in New Zealand vineyards but primarily as a minor pest (D Jordan, pers comm).

The distribution of six-spotted mite on grapevines in WA has been clarified during this study. It now includes many vineyards in the Manjimup/Pemberton region. The extent and severity of the mite in some of the vineyards here shows that the mite is now capable of being a potential pest in a reasonable proportion of the south west vineyard region of WA. Vignerons who have not yet reported the mite as being present will continue to be encouraged to check for the mite. In vineyards where the mite has caused severe leaf damage, a watching brief will be maintained.

Due to the vagaries of mite abundance, this study was unable to quantify the pest status of six-spotted mite in grapevines. The premature loss of leaf function that the mite is capable of causing would be expected to compromise the ability of the vine canopy to mature its crop. This is most critical in late maturing red varieties. Also, premature leaf loss exposes fruit to the sun and grape juice quality could be compromised. Therefore, leaf damage could lead to a reduction in both juice quality and yield in the current season. Also, the premature loss of leaf function could restrict the ability of a post vintage canopy from continuing to build the reserves in the vine structure for next season's crop. In contrast to these predictions, heavily infested Semillon in the original infested vineyard produced a normal yield the following season. The extent of damage the mite has been capable of (see cover photograph), is a cause for concern amongst vignerons. The effect on grape yield and quality requires clarification in order to justify continued research into this mite.

Field observations have shown the mite can build up to very high densities very quickly. This usually occurs after December indicating that the mite has a relatively short life cycle in the warmer summer temperatures. Symptoms of leaf damage start appearing in December and by February infestations of six-spotted mite as reflected in discoloured foliage can be very extensive. Where the mite experiences favourable conditions for such a build up, the effect on leaves suggests the vine canopy would have difficulty in ripening grapes, especially in later maturing varieties. Varieties where severe leaf damage has been observed to date include Semillon, Chardonnay, Shiraz and Merlot. In some locations, the preference for the mite for one variety over an adjacent one has been observed – Shiraz was heavily infested while an adjacent area of Merlot was only moderately infested (see front cover); blocks of Chardonnay were heavily infested while adjacent areas of Sauvignon Blanc were only lightly infested.

The study on the effect of inundative releases of predatory mites on the suppression six-spotted mite lead inadvertently to the discovery of a suite of naturally occurring predators. While

stethorus beetles had been commonly found with heavy infestations of six-spotted mites on previous occasions, this study showed for the first time that other possibly more efficient predators occur in WA vineyards – six-spotted thrips and possibly a number of species of predatory mites. Predatory mites associated with infestations of six-spotted mite were found for the first time during the 2007/08 season – in both vineyards and avocado orchards. Their abundance in avocado orchards appears to be sufficiently high to maintain pest mite numbers below damaging levels. How to protect and preserve these agents in vineyards may provide the key to the sustainable management of six-spotted mite. To date, natural control agents have not been seen to prevent explosions in mite numbers to the extent that severe leaf damage has occurred.

To exploit the naturally occurring predatory mites requires clarification of their identity. Species known to feed on six-spotted mite that require identification include those found in Manjimup apple orchards that may be feeding on two-spotted mite or apple rust mite, those that apparently occur naturally in WA vineyards and avocado orchards, and the contaminant species that occurs with PP in commercial cultures. Where releases of predatory mites were made in six-spotted mite infested vineyards in the 2007/08 season, any long term effect will not be known until the coming season.

On occasions where six-spotted mite has seemingly been absent, it has built up to large numbers in late summer very quickly. This has important implications for the management of such a pest. These include the usefulness of monitoring to provide an early warning that the mite could be a problem. Depending on the time at which the mite appears, control based on taking timely preventative action with miticide chemicals before 80% capfall could be compromised. Prior to this stage of vine growth, it could be argued that residue data might not be critical to gain product registration. However, after this time, should intervention rely on using any of the chemical miticides included on a minor use permit previously approved, residue data would need to be generated. Considering the localised nature of the distribution of six-spotted mite, it is unlikely that financial support from pesticide companies for such work would be forthcoming.

While there are problems associated with use of miticides against six-spotted mite in terms of potential for chemical residues and adverse secondary effects on other vineyard inhabiting biota, the possible role of horticultural spray oils should be examined. Spray oils have been shown to have activity against other species of mites. Such products are short lived in the environment and do not have a reputation of inducing secondary pest outbreaks. However, spray oils need to be shown to have no undesirable effects on grapes such as stripping the bloom from ripening berries. Even if the spray oils merely reduce the abundance of six-spotted mite to allow predators to become more effective and they are not harmful to vines, then spray oils could play an important role in preventing outbreaks of six-spotted mite.

No detailed studies on the biology of six-spotted mite have been undertaken in WA. Dramatic fluctuations in the abundance of the mite have compromised attempts to study the mite at specific locations for reasonable periods of time to gain a better understanding of its management. Monitoring of six-spotted mite in grapevines to date has only commenced after leaf damage has been observed – which is usually well into the season around January. Prior to this time, mite numbers are so low as to be very difficult to detect. In one of the heavily infested vineyards, leaf sampling the following season did not detect mites until near vintage. The more infested sites that are examined, the more this situation seems to occur.

Where mite monitoring has continued past vintage, breeding has been observed to occur virtually until leaf senescence. An important gap in our knowledge is the location for overwintering six-spotted mite within vineyards. Examination of a wide range of plants that occur in vineyards has shown the mites are present at extremely low levels. Infested plants included alders, nightshade, marshmallow and dock. On evergreen hosts such as avocado and citrus, the mite remains active on leaves through winter. The very large induced mortality of six-spotted mite with leaf fall in heavily infested vineyards is probably the main reason for the apparent absence of the mite on foliage the following season until well into the growing season.

Six-spotted mite appears to be a new and real threat to the health of vineyards in WA. While many unknowns exist in our understanding of its pest status and ecology, with more effort to clarify these, the mite can hopefully be reduced to just another form of prey for natural control agents.

RECOMMENDATIONS

The following are recommendations as follow-up activities from this research project:

- Quantify the pest status of six-spotted mite in WA vineyards.
- Assess a range of product options as spray treatments to control field infestations of six-spotted mite in summer on bearing vines, with an emphasis on horticultural spray oils.
- Assess the role of natural enemies in suppressing six-spotted mite – both released commercially available predatory mites and those biological control agents present naturally in WA vineyards.
- Clarify the overwintering biology of six-spotted mite in WA vineyards.
- Collaborate with the WA grapevine industries to continue to map the distribution of the mite.
- Provide continual updates to the WA winegrape industry on developments in understanding six-spotted mite.

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