# Seasonal occurrence of vine pests in commercially treated vineyards in the Hex River Valley in the Western Cape Province, South Africa

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The population fluctuations of arthropods attacking table grapes were studied in 12 commercially treated vineyards in the Hex River Valley in South Africa for three years. Sampling was conducted by inspecting different plant parts and using a variety of traps. *Planococcus ficus* (Signoret) males in the pheromone traps started increasing during December, to reach a peak at the end of February. Cordon infestation preceded bunch infestation by three to five months, the latter occurring from about January or February. Thrips, mainly *Frankliniella occidentalis* (Pergande), caught on blue sticky traps were active during spring and early summer. Damage to the berries occurred about four weeks after thrips were recorded on the sticky traps. *Phlyctinus callosus* Boh. was recorded under fluted cardboard bands tied around the stems of vines from early October, with the first bunch damage recorded towards the end of October . More *Epichoristodes acerbella* (Walker) moths were caught in pheromone traps during the cool winter months than during the hotter summer months. Damage to the bunches started during November and declined during January and February, only to increase again towards the end of February and March. Although *Helicoverpa armigera* (Hübner) moths were caught in pheromone traps, no damage ascribed to this insect was recorded. The only phytophagous mite was *Tetranychus urticae* Koch, which was active throughout the fruiting season. The most common predatory mite was *Euseius addoensis* (Van der Merwe & Reyke).

**Key words**: vine pests, generic monitoring, temporal occurrence.

## INTRODUCTION

South Africa is the second largest table grape producing country in the Southern Hemisphere, Chilé being the largest. During the 2003/2004 production season there were just over 12 300 ha of table grapes in South Africa. The total production was 269 427 tons with a value of about R1.90 billion (approximately US $270 million). The total value of table grape exports was R1.78 billion or just over 93 % of the value of the crop (Anon. 2004). However, table grapes in South Africa are infested by a number of insect pests which are not present in countries to which they are exported, such as the United States of America and Israel, giving rise to phytosanitary concerns. In addition, in these markets there are legislative restrictions on the presence of insecticide residues on fruit, which complicates the management of these insects, and of those that are not of phytosanitary importance, but which cause economic damage. In the case of phytosanitary pests there is zero tolerance and control measures are applied preventatively. Hence, it is essential that a monitoring system is sensitive enough to detect low pest levels, since even low levels may lead to fruit rejections. Knowledge of when the pests are likely to occur will be helpful in this regard in that it will give insight as to when monitoring should be initiated.

The two most important phytosanitary pests of table grapes in the Hex River Valley are the banded fruit weevil, *Phlyctinus callosus* Boh. (Coleoptera: Curculionidae), and pear leafroller, *Epichoristodes acerbella* (Walker) (Lepidoptera: Tortricidae), (Pryke 2005). These pests also cause damage to the bunches, which may not always be of economic importance. *Phlyctinus callosus* is nocturnal and shelters in bunches during the day. It is included when the grapes are packed, resulting in rejections of export consignments when detected by the inspectors (Pryke 2005). Larvae of *E. acerbella* bore into the berries resulting in rejections of export consignments when detected.

Economic pests include the grapevine mealybug, *Planococcus ficus* (Signoret) (Hemiptera: Pseudococcidae), a key pest in South African vineyards

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(De Klerk 1981; Myburgh *et al.* 1986; Walton & Pringle 2004). It has caused substantial economic losses in California, the Middle East, South America, Pakistan, South Africa and the Mediterranean (Joyce *et al.* 2001). The grapes become infested with mealybugs and are contaminated by their wax secretions, egg sacs and honeydew, with blemishes resulting in unmarketable fruit (Nel 1983; Myburgh *et al.* 1986). Severe infestation inhibits the normal ripening processes, resulting in lack of taste and colour, eventually causing the grapes to wither (De Klerk 1981; Myburgh *et al.* 1986; Blumberg *et al.* 1995). Yellowing of the leaves and premature leaf drop may occur (Myburgh *et al.* 1986; Walton & Pringle 2004). The vine becomes weakened, vigour decreases and its lifespan is shortened (De Klerk 1981; Myburgh *et al.* 1986; Joyce *et al.* 2001; Walton & Pringle 2004).

Another economic pest of table grapes is Western flower thrips, *Frankliniella occidentalis* (Pergande) (Thysanoptera: Thripidae), which causes halo spot damage. Halo spots are formed during oviposition in the berries when a small dark scar forms at the puncture site and the surrounding tissue becomes whitish, making the fruit of certain white cultivars unsightly and unmarketable (Weaver 1976; Flaherty & Wilson 1988b; Jensen *et al.* 1992). On large-berried cultivars these spots may crack when the grapes grow, allowing entry of rot organisms (Flaherty & Wilson 1988b; Jensen *et al.* 1992).

The African bollworm, *Helicoverpa armigera* (Hübner) (Lepidoptera: Noctuidae), is a sporadic pest of grapes, causing severe damage when epidemics occur (De Klerk 1981). Most damage is caused early in the season when the larvae feed on buds, blossoms, leaves and berries (De Klerk 1981; Blomefield *et al.* 1986). Deep round holes are usually eaten into the berries which may be consumed entirely (Blomefield *et al.* 1986). The fruit forms cork tissue over the injured places, inhibiting subsequent normal development, leading to malformation (Blomefield *et al.* 1986). When mature, or almost mature, fruit is infested, the wounds remain as relatively large corky holes or depressions (Blomefield *et al.* 1986).

In certain table grape producing areas, there are indirect pests, such as the two-spotted spider mite, *Tetranychus urticae* Koch (Acari: Tetranychidae), which causes leaf damage and ultimately affects plant growth (Pringle *et al.* 1986) and yield (Prischmann *et al.* 2002) without directly damaging the fruit itself. Along with the European red mite, *Panonychus ulmi* Koch, *T. urticae* is considered to be the most important pest of grapevines in Europe (Candolfi *et al.* 1992). It is also the most important spider mite pest of grapevines in dry summer regions of Europe (Schruft 1985), being especially important in Spain (Flaherty & Wilson 1988a). Threshold levels of indirect pests may also be determined and knowledge of when they occur is also important.

This study was conducted to gain information on the temporal occurrence of table grape pests in commercially treated vineyards in South Africa, creating a base from which to develop monitoring systems for the management of insect pests on table grapes. Some of the sampling methods used in the present study were developed by other researchers, but have never been combined into one generic monitoring system with which the whole table grape pest complex can be sampled.

## MATERIAL AND METHODS

### *Study sites*

The study was conducted on three farms in the Hex River Valley in the Western Cape Province of South Africa, namely Klipheuwel (19°31′E, 33°30′S), Boplaas (19°36′E, 33°30′S) and De Vlei Boerdery (19°41′E, 33°26′S). At each farm two blocks of Barlinka, a late season, black cultivar, and two blocks of Dauphine, a late season, white cultivar, were used. Each block was approximately one to two hectares in size. Twenty evenly distributed plots, each consisting of five vines between two trellising posts, were selected per block, giving a total of 100 vines per block. Therefore, a total of 1200 vines were used in the study. Farmers were not willing to leave blocks unsprayed and continued their spray programmes in all the sampling blocks. See Appendix A for a list of chemicals sprayed.

### *Temperature data*

Temperature data were obtained from the ARC – Institute of Soil, Climate and Water (AgroMet Section), Pretoria.

### *Sampling*

Sampling, consisting of physical plant inspection as well as use of traps and bands, commenced in May 2002 and continued to mid-April 2005. Plant inspections started with the cordons during the dormant stages of the vine. Cordon inspection

consisted of examining the top fork of each of the five vines per plot for the presence of *P. ficus* to a distance of within 30 cm of the main stem.

After bud break, the shoots and leaves became visible and these were inspected in addition to the cordons. The distal 15 cm of one shoot per vine was examined for shoot infestation by *P. ficus* and shoot damage caused by *P. callosus.* One leaf per vine was examined for the presence of leaf-feeding arthropods such as spider mites, *Tetranychus* spp. (Prostigmata: Tetranychidae) and *P. ficus.* After examination in the field, the leaves were placed in brown paper bags and transported, in cool bags, to the laboratory, where they were stored in a cold room prior to being examined. The leaves were brushed with a brushing machine to dislodge the insects and mites (Sabelis 1985) and all the developmental stages of the mites and their predators were counted with the aid of a microscope. Leaf samples were taken from October to the end of April, when the fruit season ended. From April onwards the quality of the leaves rapidly deteriorated until leaf fall and it became too difficult to brush the brittle leaves with the brushing machine.

After shoot and leaf emergence, the inflorescences of the vine became visible. Inspection of the latter started as soon as the inflorescences appeared and continued through flowering and berry set, until harvest of the ripe bunches. Inspection of the inflorescence will be referred to as bunch inspection. One bunch per vine was examined for the presence of insects and damage caused by insects such as *P. ficus, P. callosus, F. occidentalis, E. acerbella* and *H. armigera.*

Trap and band monitoring continued throughout the year. Fluted cardboard bands (Nel 1983; Nel & Addison 1993) were tied around the stems of one vine per plot to trap *P. callosus.* After inspection, the weevils were removed and the cardboard band was moved to the next vine in the plot.

The activity of *F. occidentalis* was monitored using a blue sticky trap (Gaum & Giliomee 1994; Chu *et al.* 2000) in four to five of the 20 plots. The sticky traps were placed outside the canopy, as this is the position where most thrips are caught (E. Allsopp, pers. comm.)

Monitoring of the plants and inspection of the cardboard bands and sticky traps were done at two-weekly intervals. The sampling dates of the 12 vineyard blocks were not the same, as they could not be sampled on one day. Two sets of six blocks each were sampled in alternate weeks.

Pheromone capsules were placed in yellow delta traps, containing a white sticky pad, at a density of one trap per block of one to two hectares to monitor the activity levels of *E. acerbella, H. armigera* and *P. ficus.* Separate traps were used for each of these pests. The traps for *E. acerbella* and *H. armigera* were placed at the height of the bunches (T. Blomefield, pers. comm.) and at the height of the cordon for *P. ficus* (Walton *et al.* 2003), with the openings parallel to the row direction in order to avoid chemicals being sprayed into the trap. *Epichoristodes acerbella* and *H. armigera* traps were inspected at weekly intervals. *Planococcus ficus* traps were placed in the vineyards during July 2003, when the traps became commercially available. The first data were recorded during August 2003. These traps were inspected at two-weekly intervals during the fruit season (September to the end of April during 2003 and 2004) (Walton *et al.* 2003; Walton *et al.* 2004) and monthly during the rest of the year (Walton *et al.* 2003).

Sampling occasionally had to be postponed due to rain. A handheld computer with Cybertracker software (http://www.cybertracker.co.za) was used to record data obtained from vine inspections, trap catches and band monitoring in the field. These data were downloaded to a computer and imported into Access, a relational database (Dowling 2000). Appropriate 'queries' were developed in order to prepare the data for analysis.

### *Temporal patterns of occurrence*

Plant inspections were conducted at intervals of two weeks in each vineyard as described above. The data (insects per sample unit and percentage infestation) for each two-weekly cycle from the 12 vineyards were averaged and plotted against date, which was determined as the day that fell in the middle of the sampling cycle. These will be referred to as the combined data. The same was done for *P. ficus* males caught in pheromone traps. *Epichoristodes acerbella* and *H. armigera* trap catches were recorded every week in all 12 vineyards. These weekly trap catches were averaged and plotted on inspection date.

### *Synchrony between phytophagous mites and their predators*

Cross correlation analysis (Chatfield 1984) was performed between the phytophagous mites and their predators to determine whether or not the population increase of predatory mites occurred

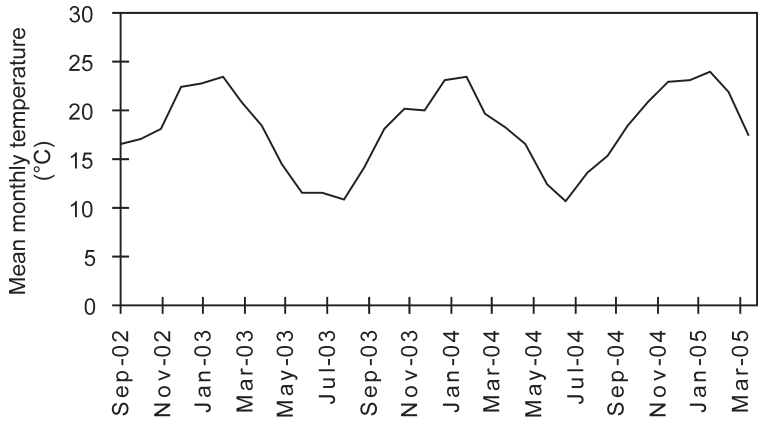


**Fig. 1**. Mean monthly temperatures in the Hex River Valley from the onset of the 2002/2003 season until the end of the 2004/2005 season.

after that of the phytophagous mites. This was performed on the combined data for each of the three seasons, as well as on the data from each individual block for the three seasons.

### *Synchrony in abundance for different sampling methods for each pest*

Cross correlations (Chatfield 1984) between bunch damage and the number of *F. occidentalis* caught on the sticky traps were performed on the combined data, as well as on the data from the individual blocks. The same was done for *E. acerbella* caught in the pheromone traps and for *P. callosus* recorded under the cardboard bands. The objective was to determine whether or not there was a time lag between trap catches and bunch damage and to quantify any time lag.

### *Simplifying pheromone trapping for* Planococcus ficus

*Planococcus ficus* cordon inspections should start when more than 65 *P. ficus* males per pheromone trap are recorded over two weeks (Walton *et al.* 2003). The sticky pads used in the pheromone traps have a counting grid, consisting of 36 blocks. The amount of time spent counting *P. ficus* males on the sticky pads in the pheromone traps could be reduced by counting the number of grid blocks with *P. ficus* males in the field and relating it to the actual number of *P. ficus* males. Therefore, for each pheromone trap and sampling date, the total number of *P. ficus* males found in the pheromone trap was regressed on the number of blocks in the grid on the sticky pad (grid blocks) in which *P. ficus* was recorded during physical inspection.

## RESULTS

### Temperature data

Temperatures in the Hex River Valley started to rise during spring, with mean monthly temperatures above 20°C usually recorded from November to March (Fig. 1). Maximum temperatures were recorded during February during all three seasons, after which they declined and reached a minimum during July to August (Fig. 1).

### *Planococcus ficus*

Cordon, shoot, leaf and bunch infestation are presented in Fig. 2B,C. In one of the blocks, no infestation was observed. In three of the blocks, no shoot infestation was observed and in one of the blocks there was no bunch or shoot infestation. However, *P. ficus* males were recorded in traps in all 12 blocks. For this reason, data on damage from all 12 blocks were included in Fig. 2B,C. Higher levels of infestation were observed in the Dauphine vineyards at Klipheuwel (not shown here, but observed during the study). *Planococcus ficus* cordon infestation preceded bunch infestation during all the seasons. The time lag between cordon and bunch infestation ranged from four months during the 2002/2003 season to five months during the 2003/2004 season and three months during the 2004/2005 season. The first bunch infestation was recorded during January 2003 and January 2005 in the 2002/2003 and 2004/2005 seasons, respectively, and February 2004 during the 2003/2004 season (Fig. 2B). *Planococcus ficus* leaf infestation occurred more or less at the same time as bunch infestation (Fig. 2B,C). Shoot

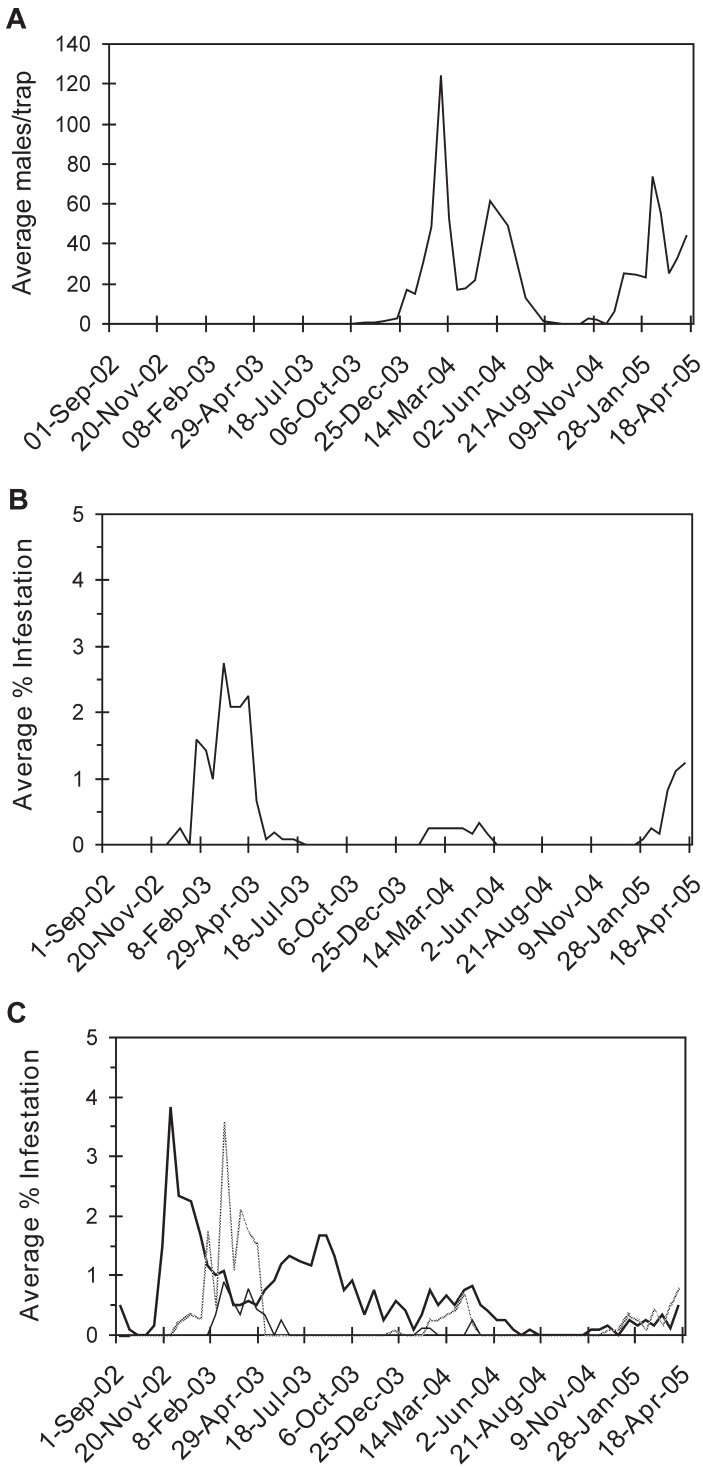


**Fig. 2**. Seasonal occurrence of *Planococcus ficus* from the onset of the 2002/2003 season until the end of the 2004/2005 season. **A**, Pheromone trap catches; **B**, bunch infestation; **C**, cordon infestation (thick solid line), leaf infestation (broken line), shoot infestation (thin solid line).

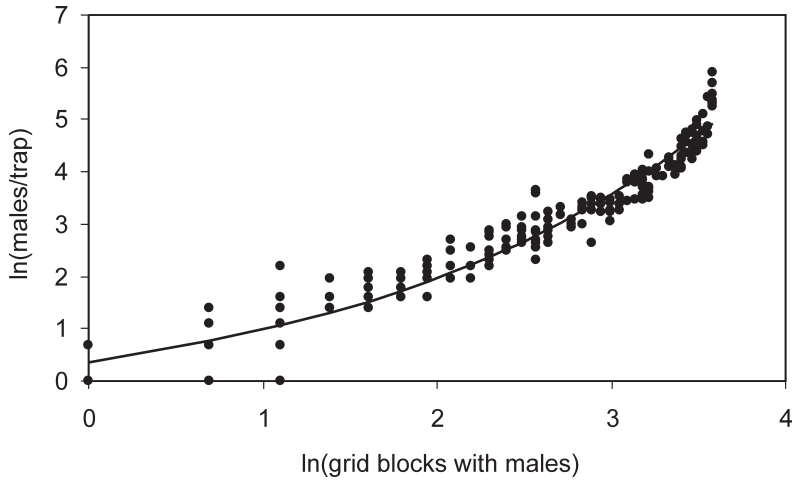


**Fig. 3**. Relationship between the total number of *Planococcus ficus* males per pheromone trap and the number of grid blocks on the sticky pad on which *P. ficus* males were present. $\ln(Y) = 0.637 + \exp[0.479 \times \{\ln(X)\}]$; $r = 0.97$.

infestation occurred later than bunch infestation during the 2002/2003 season, earlier during the 2003/2004 season and was absent from all twelve blocks during the 2004/2005 season (Fig. 2B,C). During the 2002/2003 season, when infestation levels were highest, bunch, leaf and shoot infestation showed a peak during March, just after the warmest month of the year (Fig. 1).

The presence of *P. ficus* males in the pheromone traps preceded bunch infestation by four months during the 2003/2004 season and four and a half months during the 2004/2005 season (Fig. 2A,B). During both seasons, numbers of *P. ficus* males in the pheromone traps increased during December and peaked towards the end of February (Fig. 2A). Bunch and cordon infestation were highest during the 2002/2003 season. Bunch infestation was lowest during the 2003/2004 season, while cordon infestation was lowest during the 2004/2005 season (Fig. 2B,C).

There was a good non-linear relationship between the actual number of *P. ficus* males found in the pheromone traps and the number of blocks in the grid of the sticky pads on which *P. ficus* was recorded (Fig. 3). When *P. ficus* males were present in 26 and 27 grid blocks, the number of males counted in the pheromone traps was 63 and 67, respectively.

### *Frankliniella occidentalis*

Not all of the thrips found on the sticky traps were *F. occidentalis.* The thrips complex included both phytophagous and predatory thrips. It was not possible to identify all the thrips on the sticky traps, since they could not be suitably prepared for the necessary microscopic examination. As a result, only thrips that could be easily distinguished from *F. occidentalis* due to apparent differences in size, abdominal shape and colour were not counted. Thrips were recorded from all 12 blocks and were active mainly during spring and summer (Fig. 4A). During all seasons, thrips numbers on the traps started to increase from about September or October, reaching a peak during November (Fig. 4A) when the mean monthly temperatures started to increase above 20°C (Fig. 1).

The presence of thrips on the blue sticky traps preceded halo spot damage caused by *F. occidentalis* during all the seasons (Fig. 4A). The latter also occurred in all blocks and was found from mid-November onwards. Thrips activity as well as halo spot damage was lowest during the 2002/2003 season and highest during the 2004/2005 season (Fig. 4A).

There was a good correlation between thrips caught on sticky traps and halo spot damage to the bunches with a time lag of four weeks (two sampling cycles) between trap catches and bunch damage ($r = 0.90$; $P < 0.001$) (Fig. 4B) for the combined data. For data from the individual blocks the time lag was also usually four weeks with correlations varying from $r = 0.56$ ($P < 0.001$) to $r = 0.94$ ($P < 0.001$). However, in two blocks there was a lag of only two weeks (one sampling cycle) with correlations of $r = 0.69$ ($P < 0.001$) and $r = 0.80$ ($P < 0.001$). In one of the Dauphine blocks

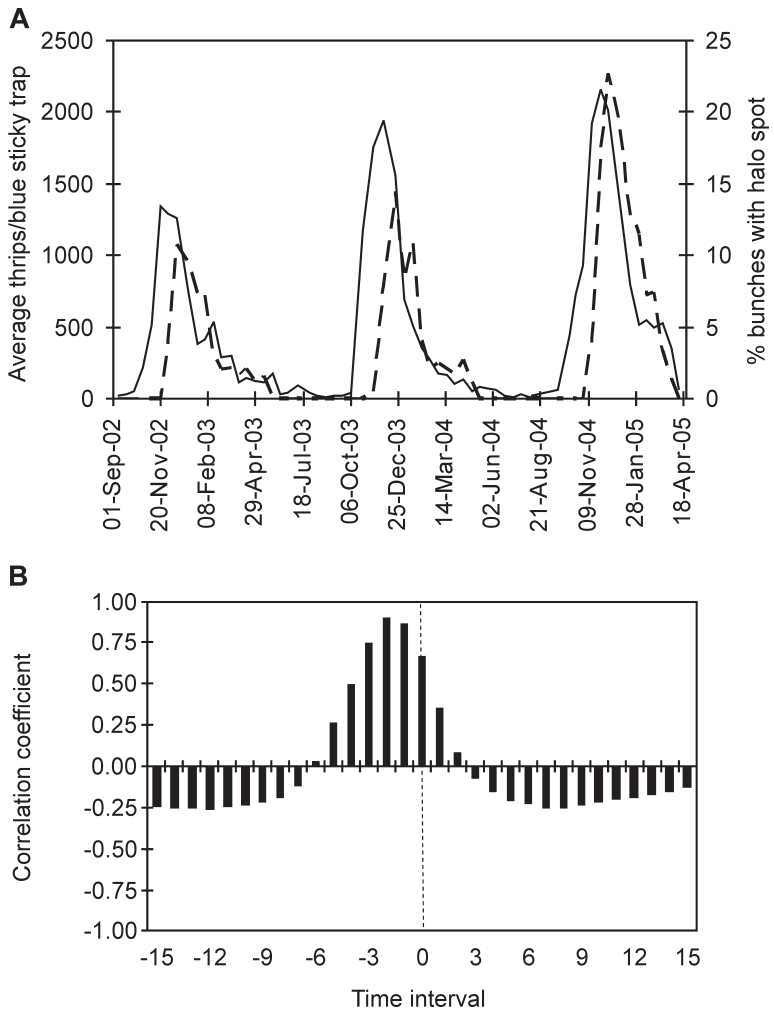


**Fig. 4**. **A**, Seasonal occurrence of *Frankliniella occidentalis* from the onset of the 2002/2003 season until the end of the 2004/2005 season. Sticky trap catches (solid line), halo spot bunch damage (broken line). **B**, Cross correlation between the average number of thrips on the blue sticky traps and halo spot bunch damage caused by *F. occidentalis* for the combined data. One time interval = two weeks.

at Boplaas, no significant time lag was observed. The time lags did not seem to be influenced by sprays applied against *F. occidentalis*. During the 2002/2003 season, sprays against *F. occidentalis* were applied only in the vineyards at Boplaas (a total of four blocks) and during the 2003/2004 and 2004/2005 seasons only in the Dauphine vineyards at Boplaas (a total of 2 blocks) (Table A1). In the Barlinka vineyards at Boplaas where sprays against *F. occidentalis* were applied, time lags of four weeks were observed as was the case with many of the vineyards where sprays against *F. occidentalis* were not applied. The blocks where time lags of two weeks were observed were not sprayed against *F. occidentalis*. The two Dauphine blocks at Boplaas received the same sprays, yet in one of the blocks there was no time lag and in the other block, a time lag of four weeks was observed.

### *Phlyctinus callosus*

No *P. callosus* damage was recorded in the blocks at Klipheuwel and a total of only four weevils were found under the cardboard bands at this farm. During the 2002/2003 season *P. callosus* activity was low in all the blocks and almost no damage was

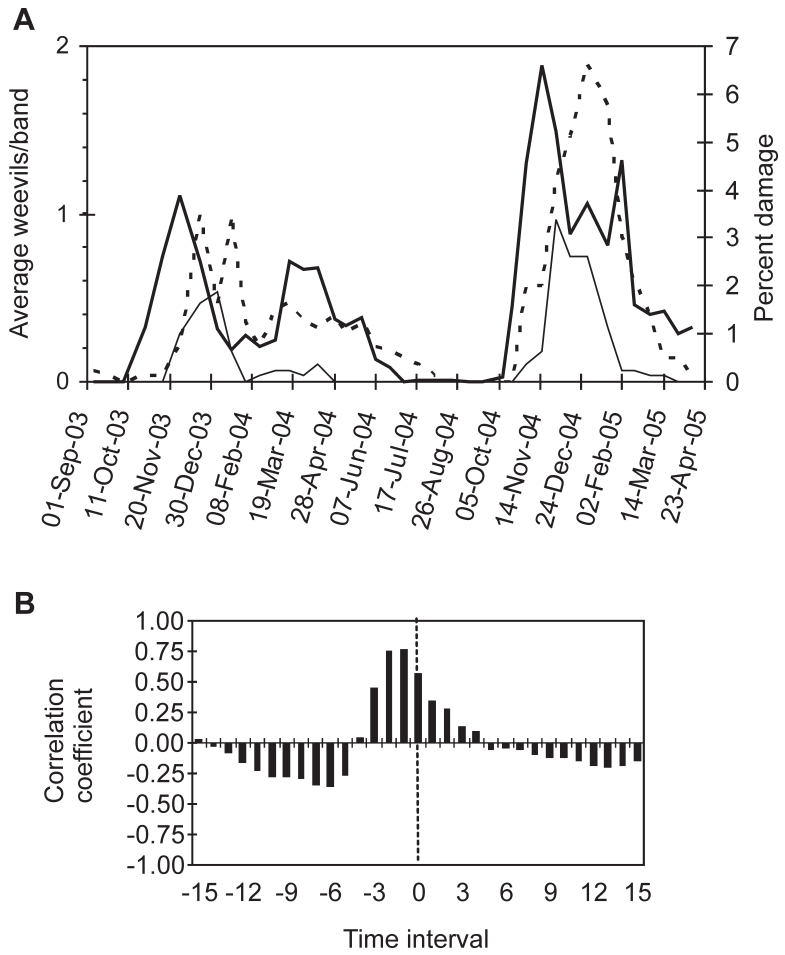


**Fig. 5**. **A**, Seasonal occurrence of *Phlyctinus callosus* from the onset of the 2003/2004 season until the end of the 2004/2005 season. Average *P. callosus* per trap or band (broad solid line), percentage bunch damage (thin solid line), percentage shoot damage (broken line). **B**, Cross correlation between *P. callosus* bunch damage and the number of weevils found under the cardboard for the combined data. One time interval = two weeks.

recorded. Consequently, these data were not included in Fig. 5A. During the remainder of the seasons *P. callosus* was found under the cardboard bands from the beginning of October, while peak numbers were recorded during November (Fig. 5A). This preceded bunch and shoot damage, which were first recorded towards the end of October or the beginning of November, while peak damage levels were recorded from November to January (Fig. 5A) when the mean monthly temperatures began to rise above 20°C (Fig. 1).

The cross correlation between the number of weevils under cardboard bands and weevil bunch damage was strong at a time lag of two weeks (one sampling cycle) ($r = 0.76$, $P < 0.001$) for the combined data (Fig. 5B). However, the cross correlations for individual blocks were only significant for data from five of the blocks. These correlations varied from $r = 0.42$ ($P = 0.011$) to $r = 0.69$ ($P < 0.001$) with time lags between zero (no lag) and eight weeks (four sampling cycles). Sprays against *P. callosus* were not applied in any of the blocks and could therefore not have influenced the time lags (Table A1).

### *Epichoristodes acerbella*

*Epichoristodes acerbella* was found in traps of all 12 blocks and moth activity peaked during spring, while the first bunch damage caused by the larvae, observed in 10 of the 12 blocks, was

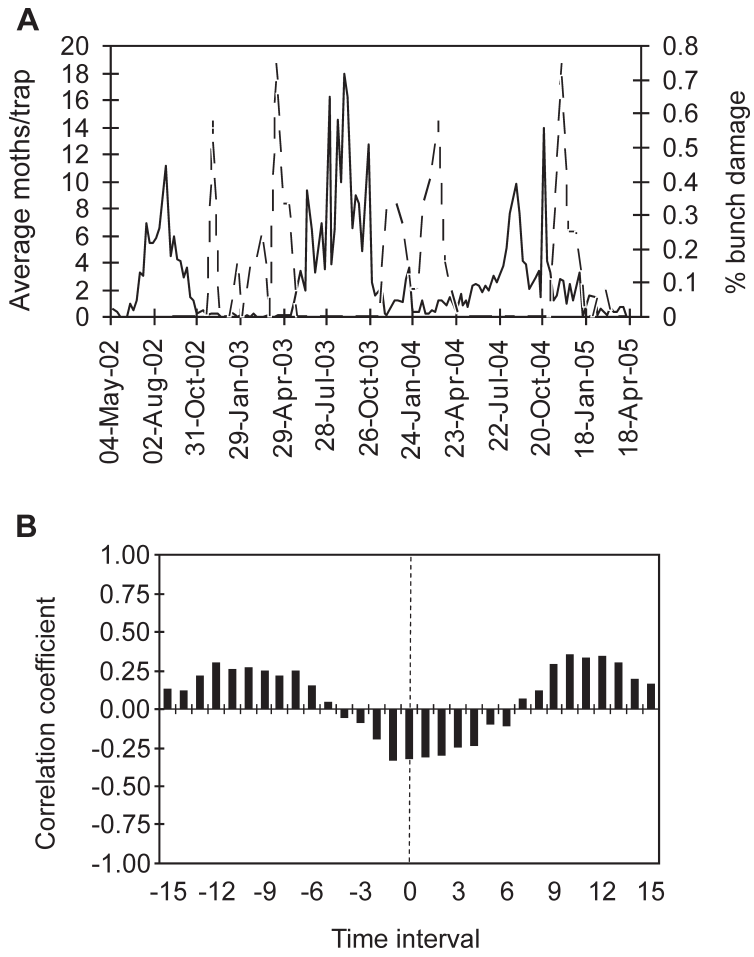


**Fig. 6**. **A**, Seasonal occurrence of *Epichoristodes acerbella* from May 2002 until the end of the 2004/2005 season. Pheromone trap catches (solid line), bunch damage (broken line). **B**, Cross correlation between numbers of *E. acerbella* caught in pheromone traps and bunch damage for the combined data. One time interval = two weeks.

recorded during the end of November (Fig. 6A). *Epichoristodes acerbella* moths were more active during the cooler times of the year (May to November) than during the warmer months (December to April) (Figs 1, 6A). During the 2003/2004 and 2004/2005 seasons, moth activity started to decline from the end of October onwards (Fig. 6A). This decline was earlier during the 2002/2003 season than during the subsequent two seasons. There was a decline in bunch infestation by the larvae towards January and February, after which incidence of larvae in the bunches increased towards the end of February and March (Fig. 6A). The lowest moth activity during the cooler months (May to November) was observed during the 2002/2003 season. However, during this season, bunch damage was highest (Fig. 6A). Thus, low moth activity did not necessarily result in low bunch damage. When looking at data from individual blocks (not shown here, but observed during the study), there was no consistent correlation between moth incidence and bunch damage.

Bunch damage occurred at a later stage than the presence of moths in the traps. However, the correlations between moth counts and larval damage were weak, although significant ($r = 0.30$; $P = 0.020$) at a time lag of 24 weeks (12 sampling cycles) for the combined data (Fig. 6B). For data from the individual blocks, a significant time lag was observed in only six of the blocks, varying between 10 weeks ($r = 0.63$, $P = 0.002$) and 22 weeks ($r = 0.27$, $P = 0.037$).

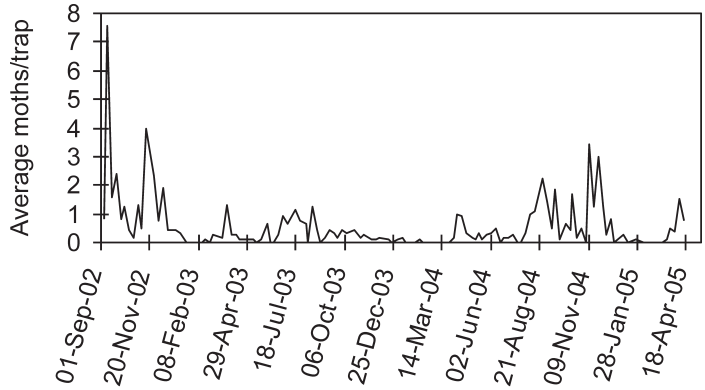


**Fig. 7**. Seasonal occurrence of *Helicoverpa armigera* from the onset of the 2002/2003 season until the end of the 2004/2005 season.

### *Helicoverpa armigera*

*Helicoverpa armigera* was recorded in traps in all vineyards. During the 2002/2003 and 2004/2005 seasons *H. armigera* numbers peaked during spring and early summer (Fig. 7), but numbers in traps were low throughout the 2003/2004 season. No bunch, bud or foliage damage, caused by the larvae, was recorded.

### Phytophagous and predatory mites

The phytophagous mites found on vine leaves were all *T. urticae.* These were observed in all vineyards and were active from October to April, with the highest numbers recorded during the warmest time of the year (Figs 1, 8). During the 2003/2004 and 2004/2005 seasons, the average *T. urticae* population reached a peak during January. During the 2002/2003 season this peak occurred during February, but numbers were lower than during the following seasons (Fig. 8).

Predatory mites were found in all vineyards. The predatory mite *Euseius addoensis* (Van der Merwe & Ryke) (Mesostigmata: Phytoseiidae) made up more than 85% of the predatory mite complex during all the seasons in the study (Table 1). The rest of the predatory mite complex consisted of *Neoseiulus californicus* (McGregor) (Mesostigmata: Phytoseiidae), *Tydeus grabouwi* (Meyer & Ryke) (Prostigmata: Tydeidae) and an undescribed phytoseiid in the genus *Typhlodromus* (Mesostigmata: Phytoseiidae) (Table 1). The latter was only found from the 2003/2004 season onwards. The predatory mites were active from mid-October. Numbers increased towards the end of the season (Fig. 8). *Tydeus grabouwi* is not an important predator (K.L. Pringle, pers. obs.) and was therefore not included in the data used in Fig. 8.

No acaracides were applied. However, mite populations are influenced by organophosphates and pyrethroids, which have a detrimental effect on predatory mites like *E. addoensis,* causing populations of *T. urticae* to increase in the absence of this

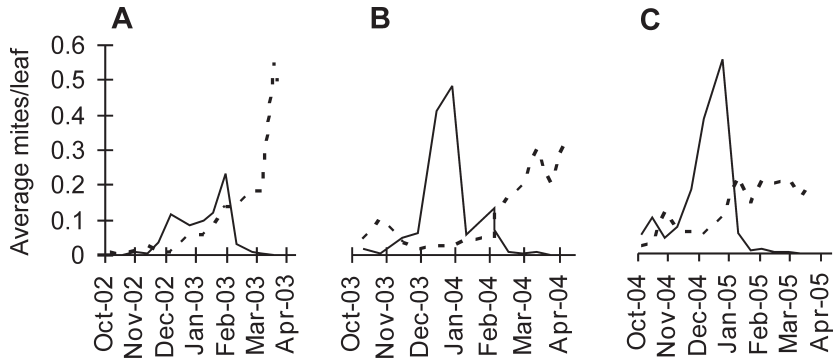


**Fig. 8**. Seasonal occurrence of *Tetranychus urticae* (solid line) and the predatory mite complex (broken line) on vine leaves for the (**A**) 2002/2003, (**B**) 2003/2004 and (**C**) 2004/2005 seasons.

**Table 1**. Percentage occurrence of each predatory mite recorded on vine leaves in the Hex River Valley for the 2002/2003, 2003/2004 and 2004/2005 seasons.

| Season | *Euseius addoensis* | *Neoseiulus californicus* | *Typhlodromus* species | *Tydeus grabouwi* |
|---|---|---|---|---|
| 2002/2003 | 97.79 | 1.95 | – | 0.25 |
| 2003/2004 | 89.08 | 3.99 | 5.03 | 1.91 |
| 2004/2005 | 86.11 | 0.87 | 10.85 | 2.17 |

natural enemy (Schwartz 1990). Organophosphates sprayed in the trial blocks were Prothiofos, Chlorpyrifos, Mevinphos and Mercapthothion (Table A1). The organophosphate sprays were mostly applied early in the season, during August and September before leaf sampling started. *Tetranychus urticae* populations did not start to increase until December, with predatory mite populations increasing from January or February onwards (Fig. 8). A few organophosphate sprays were also made during the period from October to January (Table A1). Upon inspection of the individual blocks (not shown here, but observed during the study), there was no instance where an organophosphate application lead to a decrease in the predatory mite population.

There was a time lag between the occurrence of *T. urticae* and the predatory mites on the vine leaves (Fig. 8). A cross correlation analysis on the combined data indicated that this lag was five to six sampling cycles or 10 to 12 weeks (Fig. 9). The only significant correlation was for data from the 2002/2003 season (2002/2003 season: $r = 0.71$, $P = 0.020$; 2003/2004 season: $r = 0.52$, $P = 0.185$; 2004/2005 season: $r = 0.35$, $P = 0.363$). Cross correlation analysis of data from individual blocks showed significant time lag correlations in some of the blocks, varying from 10 weeks ($r = 0.74$, $P = 0.014$) to 14 weeks ($r = 0.79$, $P = 0.021$) for the 2002/2003 season, six weeks ($r = 0.66$, $P = 0.037$) to eight weeks ($r = 0.70$; $P = 0.034$) for the 2003/2004 season, and no significant correlations for the 2004/2005 season.

## DISCUSSION

An important, yet not unexpected, observation was that for all the pests or damage caused by these pests, there were differences in occurrence between the three seasons. Many producers follow a set recommended spray programme without making use of a monitoring system. The fact that there were differences between seasons showed that such a predetermined spray programme may lead to either unnecessary sprays or under spraying.

Due to the succession of *P. ficus* infestation where cordons are the first plant part to be infested during the dormant stages of the vine, followed by bunch infestation a few months later, cordon infestation can be used as an early warning for bunch infestation. This was also observed by Walton (2003). Leaf and shoot infestation cannot be used as an early warning for bunch infestation since it did not precede the latter, and it would not be necessary to include such inspections in a monitoring system. Walton *et al.* (2003) recommended the use of pheromone traps for *P. ficus,* starting trap inspections during October. Instead of counting all *P. ficus* males found in the pheromone traps as Walton *et al.* (2003) did, the number of grid blocks with males present can be counted, thereby saving time. The presence of *P. ficus* males in 26 grid blocks on the sticky pad correlated with the threshold of 65 males per trap determined by Walton *et al.* (2003). Even though *P. ficus* counts in the pheromone traps did not start increasing until December, trap inspections should start during October or about one month after bud break to make sure the threshold is not exceeded prior to sampling. When males are found in 26 grid blocks, cordon inspections should commence.

The number of thrips caught on blue sticky traps gave a good indication of the extent of *F. occidentalis* bunch damage that could be expected four weeks later. This was however not always the case for data from the individual blocks, indicating that bunch damage predictions can only be made in general, but not for individual blocks. Despite this time-lagged correlation between thrips on sticky traps and bunch damage, the use of the sticky traps for predicting damage is not recommended, as it was extremely difficult to identify thrips on the sticky traps. Halo spot damage by thrips on the berries has been recorded early in the season, from

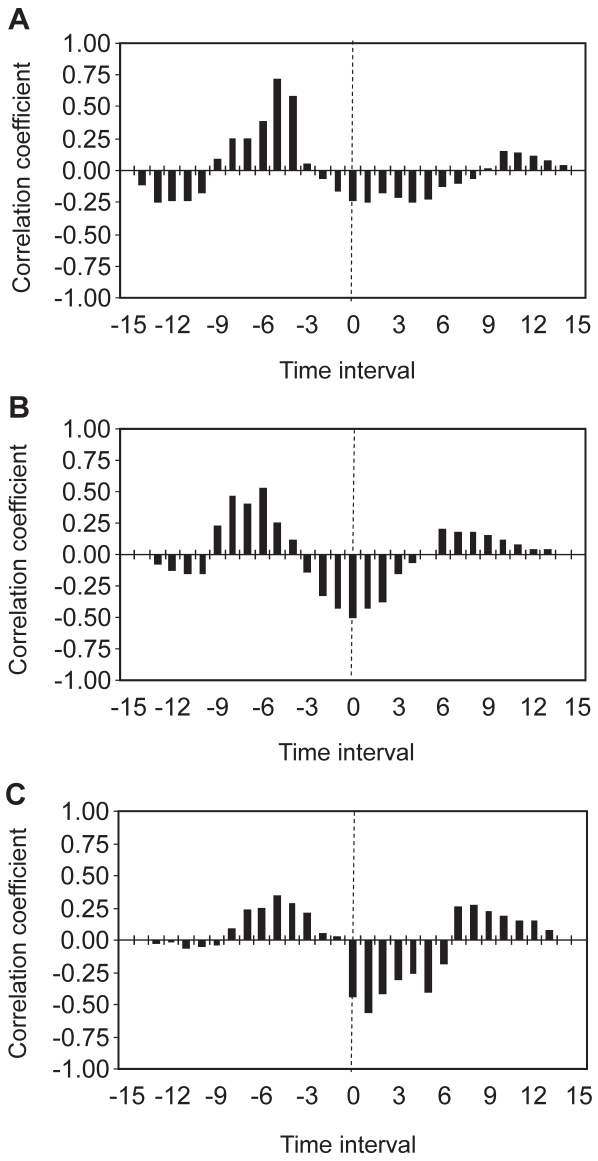


**Fig. 9**. Cross correlation between *Tetranychus urticae* and the predatory mites on vine leaves for the combined data during the (**A**) 2002/2003, (**B**) 2003/2004 and (**C**) 2004/2005 seasons. One time interval = two weeks.

the onset of bloom until fruit set (Jensen *et al.* 1992). However, in the present study it was detected only from mid-November onwards. Hence, by the time the damage was observed, it was too late to apply control measures. Bunch inspections should, however, not be excluded, since they can provide the producer with information on the infestation status of the vineyard. Bunch inspections for thrips damage should start during November or from berry set onwards. Information gained from this will only be useful in determining the infestation status and not to give growers an indication of when to apply control measures to prevent damage.

*Phlyctinus callosus* shoot and bunch damage occurred simultaneously, thus shoot damage cannot be used as an early warning system for bunch damage and need not be included during monitoring. Bunch damage predictions based on band counts cannot be made in individual blocks.

This was similar to observations in apple orchards (Nel 1983). However, the presence of weevils under the cardboard bands could be used to identify vineyards where *P. callosus* was present and consequently where phytosanitary problems may arise for the U.S.A. and Israeli markets. Monitoring using bands should start during the mid-September or from bud break onwards in order to ensure that the onset of weevil activity is recorded. The presence of weevils can be expected from October onwards, as observed during this study, as well as by Barnes *et al.* (1986), who observed weevil emergence in apple orchards during spring. Monitoring of the bunches should be initiated during the beginning of October or from flower separation or even flowering onwards, since damage to the stems of flowers, which will become berries, may already occur at this stage.

Although *E. acerbella* moths were found in the pheromone traps before bunch damage by the larvae was recorded, the number of *E. acerbella* moths found in the pheromone traps did not provide an indication of the amount of bunch damage that could be expected. Thus, the pheromone traps could only be used to identify vineyards where this pest was present and consequently where phytosanitary problems might arise. Adult *E. acerbella* activity recorded in the present study was similar to previous findings (Blomefield & Du Plessis 2000) in that it also increased from May onwards. However, in the present study it did not remain at a high level only until August as observed by Blomefield & Du Plessis (2000), as high moth counts were recorded until October. The decline from October onwards may have been due to an increase in temperatures, since this moth is sensitive to high temperatures (Bolton 1979; De Villiers 2006). A decline in larval activity was observed later during the warm January to February period. Trap inspections for *E. acerbella* moths should start during May, since high moth activity during winter months prior to the fruit season may lead to larval activity later in the fruit season. Bunch inspections should commence during the beginning of November or from berry set onwards.

As was the case with *E. acerbella,* pheromone traps for *H. armigera* can only be used to identify vineyards where this pest is present and where phytosanitary problems may arise if larvae are found in the bunches. Although no damage was recorded during the present study, larvae have been found in bunches in other grape producing areas in South Africa. In areas where there is a history of *H. armigera* damage, trap inspections for moths should start during September or from bud break onwards, with the onset of the fruit season.

In the present study, *T. urticae* was not regarded as an important pest, due to low population numbers. There are, however, certain table grape producing areas where this pest causes substantial economic losses. *Tetranychus urticae* was recorded at an earlier stage than in Europe where these mites did not colonize the foliage prior to summer (Schruft 1985). In the present study, population levels of *T. urticae* in the Hex River Valley during October were very low, with higher population levels occurring a few months later. However, Schwartz (1990) recorded high numbers of *T. urticae* on vine leaves in the Hex River Valley during October. Sabelis (1985) recommended initiating sampling for phytophagous mites within about a month of the new leaves unfolding. Thus, in areas with a history of economic damage caused by *T. urticae,* sampling should be initiated during October or one month after bud break. Since farmers do not have brushing machines or microscopes, sampling for *T. urticae* should be based on presence-absence sampling, where leaves are merely identified as infested or uninfested (De Villiers 2006). Workers should be trained to distinguish tetranychid mites from other small arthropods such as thrips.

Predatory mites in the family Phytoseiidae can be divided into four main groups or types based on their life styles, with type I being specialized predators of *Tetranychus* mites, type II being selective predators of mites in the family Tetranychidae, type III being generalist predators and type IV specialized pollen feeders and generalist predators (McMurtry & Croft 1997). Type I phytoseiids can rapidly increase in numbers when there is an increase in spider mite populations. However, this may lead to overexploitation of the spider mites and they may die or leave the area because they cannot feed on alternate food sources (McMurtry & Croft 1997). No type I phytoseiids were found in the present study. Type II, III and IV phytoseiids are not dependent on *Tetranychus* mites. Type II predators can feed on any mites in the family Tetranychidae; Type III, on a range of small arthropods, including insects; Type IV can exploit protein sources that are not of animal origin, such as pollen and fungal spores. In a biological control system, Types III and IV have the advantage of

**Table 2**. Summary of sampling procedures for monitoring population levels of the main table grape pests in the Hex River Valley.

| Pest | Sampling method | Frequency | Phenological stage or time period |
|---|---|---|---|
| *Planococcus ficus* | Pheromone traps | Biweekly | One month after bud break (October) to harvest |
| | Cordon inspections | Biweekly | After males have been found in 26 grid blocks on sticky pad |
| | Bunch inspections | Biweekly | Two months after first cordons were infested |
| *Frankliniella occidentalis* | Bunch inspections | Biweekly | Berry set (November) to harvest |
| *Phlyctinus callosus* | Cardboard bands | Biweekly | Bud break (mid-September) to harvest |
| | Bunch inspections | Biweekly | Flower separation (October) or flowering to harvest |
| *Epichoristodes acerbella* | Pheromone traps | Weekly | Dormancy (May) to harvest |
| | Bunch inspections | Biweekly | Berry set (November) to harvest |
| *Helicoverpa armigera* | Pheromone traps | Weekly | Bud break (September) to harvest |
| | Bunch inspections | Biweekly | Berry set (November) to harvest |
| *Tetranychus urticae* | Leaf inspections | Biweekly | One month after bud break (October) to harvest |

being able to establish and survive in the absence phytophagous mites. The most abundant predatory mite found in this study, *E. addoensis,* is a type IV phytoseiid (McMurtry & Croft 1997). It is able to keep *T. urticae* below economically damaging levels in vineyards where no organophosphate and pyrethroid sprays are applied (Schwartz 1990). *Neoseiulus californicus* is rated between a type II and a type III phytoseiid (McMurtry & Croft 1997; Croft *et al.* 1998; Jung & Croft 2001), so it can feed on arthropods other than spider mites and it may also feed on pollen (Croft *et al.* 1998). Tydeid mites will feed on various plant and animal food sources (Gerson *et al.* 2003). Although *T. grabouwi* is not an important predator, it may serve as a food source for some of the other predatory mites (Gerson *et al.* 2003). The predatory mites may have contributed to the reduction of *T. urticae* populations towards the end of the season.

Information gained here regarding the time at which pests appear in commercially treated vineyards can now be used to develop a monitoring system for the table grape pest complex in the Hex River Valley. The next step will be to determine sampling errors and ultimately the reliability of decisions regarding control intervention. Results obtained in this study indicated that monitoring for the different pests should start at different times following phenological stages of the vine (Table 2). During the dormant stages of the vine, trap inspections for *E. acerbella* should commence. At bud break, trap inspections for *H. armigera* should start in areas where this pest is considered to be a problem. This is also the time when band inspections for *P. callosus* should commence. About one month after bud break, trap inspections for *P. ficus* should commence. Cordon inspections for *P. ficus* should start after males are recorded in 26 grid blocks on the sticky pad. Although a lag of at least three months between cordon and bunch infestation was observed in the present study, bunch inspections for *P. ficus* can commence about two months after the first cordon infestation is observed. This will ensure that unacceptable levels of bunch infestation do not occur. Leaf inspections for *T. urticae* should also start about one month after bud break if the latter is regarded as a problem. At flower separation or flowering, bunch inspections for *P. callosus* should start. At berry set, bunch inspections for *F. occidentalis* and *E. acerbella* should commence.

Even though *H. armigera* bunch damage was not observed in the present study, bunch inspections for this pest should also start at berry set in areas where it is considered to be a problem. However, in a generic monitoring system, one system will be used for all pests. Therefore, for pests causing bunch damage, inspections should start as soon as damage can be expected. In the case of this study, this was at flower separation, which was the time when damage by *P. callosus* could be expected. The information on time of season when bunch damage by the other pests were first recorded, can be used as an indication of when to expect damage by these pests.

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**Table A1**. Insecticides sprayed against pests at Klipheuwel (KH), Boplaas (BP) and De Vlei Boerdery (DV).

| Farm | Season | Pest | Chemicals | Time and frequency |
|---|---|---|---|---|
| KH | 02/03 | Spray programmes were not available | | |
| | 03/04 | *P. ficus* | Prothiofos | 1 spray during mid-November |
| | 04/05 | *P. ficus* | Chlorpyrifos | 2 sprays, 2 weeks apart, during mid- and late August |
| BP | 02/03 | *P. ficus* | Chlorpyrifos | 2 sprays, 2 weeks apart, during early and late August (Barlinka only); 1 spray during mid-September (Dauphine only) |
| | | *Colomerus vitis* | Bromopropylate | 2 sprays, 2 weeks apart, during early and mid-October |
| | | *E. acerbella* | *Bacillus thuringiensis* var. Kurstaki | 5 sprays from early October to late January, at intervals of 6 weeks, 2 weeks, 6 weeks and 2 weeks |
| | | *F. occidentalis* | Formetanate and sugar | 1 spray during late October (Dauphine) or early November (Barlinka) |
| | | *H. armigera* | *Bacillus thuringiensis* var. Kurstaki | 2 sprays, 2½ weeks apart, during mid- and late December |
| | 03/04 | *P. ficus* | Chlorpyrifos; Prothiofos; Mevinphos | 2 Chlorpyrifos sprays, 2 weeks apart, during mid- and late August (Barlinka) or late August and early September (Dauphine); 1 Prothiofos spray (Dauphine only) during late October; 1 Mevinphos spray (Barlinka only) during early January |
| | | *Colomerus vitis* | Endosulfan | 2 sprays, 2 weeks apart, during late October and early November (Barlinka) or 1 spray during late October (Dauphine) |
| | | *E. acerbella* | *Bacillus thuringiensis* var. Kurstaki | 4 sprays, at 2-weekly intervals, from late November to late December (Barlinka) or from early November to mid-December (Dauphine) PLUS 2 sprays (Dauphine only) during early and mid-January |
| | | *F. occidentalis* | Formetanate and sugar | 1 spray during mid-November (Dauphine only) |
| | 04/05 | *Colomerus vitis* | Endosulfan | 1 spray during late October |
| | | *F. occidentalis* | Spinosad | 1 spray during early November (Dauphine only) |
| | | *E. acerbella* | *Bacillus thuringiensis* var. Kurstaki | 3 sprays, at 2-weekly intervals, from early November to early December PLUS 2 sprays, 2 weeks apart, during early and mid-January |
| DV | 02/03 | *P. ficus* | Chlorpyrifos | 1 spray during late August (Barlinka) or early September (Dauphine) |
| | | *E. acerbella* | Endosulfan; *Bacillus thuringiensis* var. Kurstaki | 2 Endosulfan sprays, 1 to 2 weeks apart, during early and mid-October; 5 *Bacillus thuringiensis* sprays, at 2-weekly intervals, from late October to late December PLUS 2 monthly *Bacillus thuringiensis* sprays (Barlinka only) during late January and mid-February |
| | | *Ceratitis* spp. | Mercapthothion & protein | 1 spray during late November (Dauphine only) |
| | 03/04 | *P. ficus* | Chlorpyrifos; Mevinphos | 1 Chlorpyrifos spray during early August; 1 Mevinphos spray during mid-January |
| | | *E. acerbella* | Endosulfan; *Bacillus thuringiensis* var. Kurstaki | 3 Endosulfan sprays, at 2-weekly intervals, from mid-October to mid-November; 6 *Bacillus thuringiensis* sprays, at 2- to 3-weekly intervals, from late November to mid-February |
| | | *Ceratitis* spp. | Mercaptothion & Protein | 1 spray during mid-December |
| | 04/05 | *P. ficus* | Chlorpyrifos | 1 spray during early August |
| | | *E. acerbella* | Endosulfan; *Bacillus thuringiensis* var. Kurstaki | 2 Endosulfan sprays, 2 weeks apart, during late September & mid-October (1 Dauphine vineyard without first spray); 4 *Bacillus thuringiensis* sprays, at 2-weekly intervals, from early November to mid-December PLUS 2 *Bacillus thuringiensis* sprays (Barlinka only), 1 week apart, during late January |

**Table A2**. Fungicides sprayed against diseases at Klipheuwel (KH) and Boplaas (BP).

| Farm | Season | Disease | Fungicide | Time and frequency |
|---|---|---|---|---|
| KH | 02/03 | Spray programmes were not available | | |
| | 03/04 | Reasons for spraying were not given, but may include the following: powdery mildew (white rust) (sprays 1, 2, 4–6, 7 (both Barlinka and Dauphine), 8, 9 (both Barlinka and Dauphine), 10, 11) and downy mildew (sprays 2–6, 7 (Dauphine only)) | Spiroxamine; Sulphur; Mancozeb; Trifloxystrobin; Cymoxanil/Propineb; Kresoxim-methyl; Copper ammonium carbonate; Penconazole; Copper oxychloride/Sulphur | 11 sprays, at 2-weekly intervals, from mid-October to early March, in the following order: Spiroxamine, Sulphur & Mancozeb (sprays 1 to 3), Trifloxystrobin, Cymoxanil/Propineb & Sulphur (spray 4), Kresoxim-methyl & Cymoxanil/ Propineb (spray 5), Kresoxim-methyl & Copper ammonium carbonate (spray 6), Penconazole (spray 7, Barlinka) or Penconazole & Copper ammonium carbonate (spray 7, Dauphine), Penconazole (spray 8), Copper oxychloride/Sulphur (spray 9, Barlinka) or Penconazole (spray 9, Dauphine), Copper oxychloride/Sulphur (sprays 10 & 11) (Dauphine vineyards without spray 11) |
| | 04/05 | Reasons for spraying were not given, but may include the following: powdery mildew (white rust) (sprays 1–9), downy mildew (sprays 1–4, 9, 10) and Botrytis rot (spray 3) | Mancozeb; Spiroxamine; Sulphur; Cymoxanil/ Propineb; Trifloxystrobin; Iprodione; Kresoxim-methyl; Penconazole, Azoxystrobin; Copper ammonium carbonate | 9 sprays, at two-weekly intervals, from mid-October to early February, in the following order: Mancozeb, Spiroxamine & Sulphur (spray 1), Spiroxamine, Cymoxanil/Propineb & Sulphur (spray 2), Trifloxystrobin, Cymoxanil/Propineb, Sulphur & Iprodione (spray 3), Cymoxanil/Propineb & Kresoxim-methyl (spray 4), Penconazole (sprays 5 to 7), Kresoxim-methyl (spray 8), Azoxystrobin (spray 9) PLUS 1 Copper ammonium carbonate spray 3 days after spray 9 (spray 10) |
| BP | 02/03 | Powdery mildew (white rust) | Pyrifenox; Sulphur; Pyraclostrobin; Fenarimol; Copper oxychloride/Sulphur; Folpet/Sulphur | 13 sprays, at 1- to 2-weekly intervals, from early October to late January, in the following order: Pyrifenox (spray 1), Sulphur (sprays 2 & 3), Pyraclostrobin (sprays 4 & 5), Fenarimol (spray 6), Sulphur (spray 7), Fenarimol (spray 8), Copper oxychloride/Sulphur (spray 9), Fenarimol (sprays 10 & 11), Copper oxychloride/Sulphur (spray 12), Fenarimol (spray 13) PLUS 2 Folpet/Sulphur sprays, 1 during late February & 1 during mid-March |
| | | Downy mildew | Mancozeb; Fosetyl-Al/Mancozeb; Strobulirine; Azoxystrobin | 1 Mancozeb spray during early October; 1 Fosetyl-Al/Mancozeb spray during mid-October; 1 Pyraclostrobin spray during mid-November; 1 Azoxystrobin spray (Dauphine only) during late December |
| | | Botrytis rot | Iprodione | 1 spray during mid-November & 1 spray during mid-March (Barlinka) or late March (Dauphine) |
| | 03/04 | Powdery mildew (white rust) | Spiroxamine; Sulphur; Pyraclostrobin; | 12 sprays, at 1- to 2-weekly intervals, from early October to late January, in the following order: Spiroxamine (sprays 1 & 2), Sulphur (sprays 3 to 5) (Pyraclostrobin was used for spray 4 in Dauphine vineyards), Pyraclostrobin (spray 6, Barlinka) or Kresoxim-methyl (spray 6, Dauphine), Sulphur (spray 7), Fenarimol (sprays 8 to 11), Sulphur (spray 12) PLUS 1 Sulphur spray, 3 weeks after spray 12 (mid-February) |
| | | Downy mildew | Kresoxim-methyl; Fenarimol Mancozeb; Fosetyl-Al/Mancozeb | 4 sprays, at 2-weekly intervals, from mid-October to late November, in the following order: Mancozeb (sprays 1 & 2), Fosetyl-Al/Mancozeb (spray 3, Barlinka) or Mancozeb (spray 3, Dauphine), Mancozeb (spray 4) (Dauphine vineyards without spray 4) |
| | | Botrytis rot | Iprodione | 1 spray during early March |

| Farm | Season | Disease | Fungicide | Time and frequency |
|---|---|---|---|---|
| | 04/05 | Powdery mildew (white rust) | Spiroxamine; Sulphur; Pyraclostrobin; Kresoxim-methyl; Copper oxychloride/Sulphur; Fenarimol; Folpet/Sulphur | 6 sprays, at 1- to 2-weekly intervals, from late October to early December, in the following order: Spiroxamine (spray 1), Sulphur (spray 2), Pyraclostrobin (spray 3), Kresoxim-methyl (spray 4), Copper oxychloride/Sulphur (spray 5), Fenarimol (spray 6) PLUS 4 sprays, at 1-weekly intervals, from early January to late January, in the following order: Fenarimol (spray 1), Copper oxychloride/Sulphur (spray 2), Fenarimol (sprays 3 & 4) PLUS 1 Folpet/Sulphur spray during late February |
| | | Downy mildew | Fosetyl-Al/Mancozeb; Mancozeb; Azoxystrobin | 1 Fosetyl-Al/Mancozeb spray during late October; 1 Mancozeb spray during early November; 1 Azoxystrobin spray during early December |
| | | Botrytis rot | Iprodione | 1 spray during mid-December (Barlinka) or late February (Dauphine) |

**Table A3**. Fungicides sprayed against diseases at De Vlei Boerdery (DV).

| Farm | Season | Disease | Chemical | Time and frequency |
|---|---|---|---|---|
| DV | 02/03 | Powdery mildew (white rust) | Sulphur; Kresoxim-methyl; Copper oxychloride/Sulphur; Fenarimol | 7 sprays, at 1- to 2-weekly intervals, from early October to mid-December, in the following order: Sulphur (sprays 1 & 2), Kresoxim-methyl (sprays 3 & 4), Sulphur (spray 5, Barlinka) or Copper oxychloride/Sulphur (spray 5, Dauphine), Fenarimol (sprays 6 & 7) PLUS 7 sprays (Barlinka only), at 1- to 2-weekly intervals, from late December to late February, alternating between Sulphur (sprays 1, 3, 5 & 7) and Fenarimol (sprays 2, 4 & 6) OR 11 sprays (Dauphine only), at 1- to 2-weekly intervals, from late December to early March, alternating between Fenarimol (sprays 1, 3, 5, 7 & 9) and Sulphur (sprays 2, 4, 6, 8, 10 & 11) |
| | | Downy mildew | Mancozeb; Cymoxanil/Mancozeb | 4 sprays, at 1- to 2-weekly intervals, from early October to mid-November, in the following order: Mancozeb (spray 1); Cymoxanil/Mancozeb (Spray 2), Mancozeb (sprays 3 & 4) |
| | | Botrytis rot | Iprodione | 1 spray during early January PLUS 2 sprays (Barlinka only), 1 during late February and 1 during early March OR 1 spray (Dauphine only) during mid-March |
| | 03/04 | Powdery mildew (white rust) | Sulphur; Trifloxystrobin; Fenarimol | 15 sprays, at 1- to 2-weekly intervals, from mid-October to early March, in the following order: Sulphur (sprays 1 & 2), Trifloxystrobin (spray 3), Fenarimol (sprays 4 & 5), Sulphur (spray 6), Fenarimol (spray 7), Sulphur (spray 8), Fenarimol (spray 9), Sulphur (spray 10), Fenarimol (spray 11), Sulphur (spray 12), Fenarimol (spray 13), Sulphur (sprays 14 & 15) |
| | | Downy mildew | Mancozeb; Cymoxanil/Mancozeb | 3 sprays, at 2-weekly intervals, from mid-October to mid-November, in the following order: Mancozeb (sprays 1 & 2), Cymoxanil/Mancozeb (spray 3) |

| Farm | Season | Disease | Chemical | Time and frequency |
|---|---|---|---|---|
| | 04/05 | Powdery mildew (white rust) | Sulphur; Trifloxystrobin; Kresoxim- methyl; Fenarimol | 8 sprays, at 1- to 2-weekly intervals, from late September to late December, in the following order: Sulphur (sprays 1 to 3) (one Dauphine vineyard without spray 1), Trifloxystrobin (spray 4), Kresoxim-methyl (spray 5), Fenarimol (spray 6), Sulphur (spray 7), Fenarimol (spray 8) PLUS 6 sprays (Barlinka only), at 2- to 6-day intervals, from mid-January to late January, alternating between Sulphur (sprays 1, 2, 4 & 6) and Fenarimol (sprays 3 & 5), followed by another Sulphur spray during early March OR 5 Sulphur sprays (Dauphine only), at 1-weekly intervals, from mid-January to early-February |
| | | Downy mildew | Mancozeb; Cymoxanil/Mancozeb; Phosphorous acid; Dioxy-MP14; Azoxystrobin; Sulphur | 2 Mancozeb sprays, 2 weeks apart, during late September & mid-October; 1 Cymoxanil/Mancozeb spray during late October; 1 Phosphorous acid spray during early December PLUS, in Dauphine vineyards, 1 Azoxystrobin spray during early January and 1 Dioxy-MP14 spray during late January OR, in Barlinka vineyards, 2 Azoxystrobin sprays, 2 weeks apart, during late December and early January, followed by 5 sprays, at 1- to 3-day intervals, from mid- to late February, in the following order: Dioxy-MP14 (spray 1), Azoxystrobin (spray 2), Dioxy-MP14 (spray 3), Sulphur (sprays 4 & 5) |
| | | Botrytis rot | Iprodione | 1 spray during mid-November PLUS 1 spray during early February (Dauphine) or late February (Barlinka) |