

## NATURAL ENEMIES OF CITRUS RED MITE (*PANONYCHUS CITRI*) IN CITRUS ORCHARDS

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### ABSTRACT

Citrus red mite (CRM) populations can reach high levels in citrus orchards after the application of broad-spectrum pesticides to control other pests. It is important to know which are the key biocontrol agents of CRM in New Zealand in order to minimise use of pesticides toxic to these natural enemies. CRM and natural enemies were monitored in seven orchards from January 2004 to March 2005. Ladybirds, *Stethorus* sp. and *Halmus chalybeus*, and predatory mites, *Agistemus longisetus*, *Amblyseius largoensis* and *Phytoseiulus persimilis*, were observed consuming CRM. *Stethorus* sp. and *A. longisetus* were the most abundant natural enemies found with CRM. The presence of 0.5 live *Stethorus* sp. per leaf and 0.5-1 *A. longisetus* per leaf was associated with the decline of CRM populations (15 eggs and 15 juvenile/adults per leaf) to 'trace' levels in 4-5 weeks. The use of neonicotinoid products can disrupt the predatory activity of *Stethorus* sp. against CRM.

**Keywords:** citrus red mite, *Panonychus citri*, *Stethorus* sp., *Agistemus longisetus*, biological control.

### INTRODUCTION

Citrus red mite (CRM) (*Panonychus citri* McGregor) is one of the key pests of citrus in New Zealand (Pyle & Stevens 2004). Nymphs and adults feed on leaves and fruit producing tiny grey or silvery spots (stippling). Damage to leaves inhibits photosynthesis and increases transpiration and severe infestations can lead to necrosis, premature leaf fall, shoot dieback and decreased plant vigour (Kranz 1977).

CRM is usually considered to be a 'pesticide induced' pest whereby the broad-spectrum activity of some insecticides targeting other pests disrupts the activity of the natural enemies that usually regulate the CRM population. The long-term solution to CRM control is to eliminate the use of agrichemicals that disturb the activity of natural enemies of CRM. While some pesticides are toxic across a wide range of natural enemy groups, others may be relatively harmless to some groups such as predator mites or coccinellid ladybirds. It is important to know which are the key predators providing biocontrol of CRM in New Zealand in order to minimise use of pesticides that are toxic to these natural enemies.

The aims of this research were to identify the key natural enemies of CRM, to monitor disruption of these natural enemies and to monitor situations whereby natural enemies reduce CRM populations.

### METHODS

#### Identifying natural enemies of CRM

Four orchards (Table 1, Orchards 1-4) were monitored on 7-12 occasions between January 2004 and March 2005. At each orchard a sample of 10-20 leaves was removed

from each of 10-20 randomly selected trees within a block, placed in a plastic Minigrip™ bag and stored at 8°C until assessment. Each leaf was scanned under 10X magnification and the number of CRM eggs, juveniles and adults was recorded as well as the number of coccinellids and predatory mites. Evidence of the previous presence of ladybirds (larval moults, pupal cases and egg cases) was also recorded. From January until June 2004 predatory mites were collected and identified by Landcare Research (voucher specimens retained in New Zealand Arthropod Collection). Formal identifications were undertaken on a subset of all of the predatory mites found. From July 2004 up to 10 larval and adult coccinellids and predatory mites found were observed for five minutes in the presence of CRM to determine the life stages of CRM they fed on. Observations were made using the leaves sampled if all life stages of CRM were present, or by placing predators on prey-infested leaves or fruit.

**TABLE 1: Description of sites where the abundance of CRM and natural enemies was monitored.**

Orchard	Location	Citrus variety	No. monitoring occasions (monitoring period)	Insecticides applied <sup>1</sup>
1	Auckland	Yen Ben lemons	8 (Jan 04–Mar 05)	Yes
2	Auckland	Villa Franca lemons	7 (Mar 04–Mar 05)	Yes
3	Kerikeri	Yen Ben lemons	11 (Apr 04–Mar 05)	Yes
4	Kerikeri	Encore mandarins	12 (Jan 04–Mar 05)	No
5	Te Puke	Meyer lemons	1 (Feb 04)	Yes
6	Kerikeri	Yen Ben lemons	4 (Feb 04–Apr 05)	No
7	Auckland	Meyer lemons	3 (Mar 04–Apr 05)	No

<sup>1</sup>“Yes” indicates insecticides were applied during the monitoring period. Insecticides were applied at Orchards 4, 6 and 7 prior to commencing monitoring.

### Disrupting natural enemies of CRM

In December 2004 a small-plot field trial at Orchard 5 (Table 1) was initiated to compare the effect of six insecticide treatments on Kelly’s citrus thrips with an unsprayed control (Table 2). Each insecticide treatment was applied to single-tree plots and there were five replicates in a randomised block design. Sprays were applied to the point of runoff (ca 2000 litres/ha) using a four-nozzle air shear handgun from a Comet P48 pump. Spray application dates are given in Table 2. On 9 February 2005, one month after the final spray application, 10 leaves were picked from each plot and assessed as described above to determine the disruptive effect of each insecticide on natural enemies of CRM.

**TABLE 2: Dates of spray applications for disruption trial.**

Treatments (active ingredient/100 litres)	Application dates		
Calypso (thiacloprid 20 ml)	1 Dec 03	24 Dec 03	12 Jan 04
CGA293343 (thiamethoxam 30 g)	1 Dec 03	24 Dec 03	12 Jan 04
Orthene (acephate 80 g)	1 Dec 03	24 Dec 03	12 Jan 04
Success (spinosad 40 ml + Latron 40 ml)	1 Dec 03	15 Dec 03	31 Dec 03
Avid (abamectin 37.5ml + Excel oil 500 ml)	1 Dec 03		12 Jan 04
Surround (kaolin 100 g)	1 Dec 03		12 Jan 04
Unsprayed			

### Natural enemies reducing the abundance of CRM

From February until April 2005 samples of 10-20 leaves were taken from five single-tree plots every 2-3 weeks at two orchards (Table 1, Orchards 6 and 7) where CRM populations were high. At Orchard 6 leaves were assessed as described above, while at Orchard 7 only the numbers of juveniles/adults and the number of live *Stethorus* sp. and predatory mites on each leaf were recorded.

### Statistical analysis

For the disruption trial, the number of CRM eggs and juveniles/adults and the number of live, dead and evidence of *Stethorus* sp. was compared amongst insecticide treatments using analysis of variance (ANOVA). Least significant differences (LSDs) were calculated to separate treatments if the ANOVA resulted in a  $P < 0.05$ . The analysis was performed using the statistics programme GenStat (version 6.1).

## RESULTS

### Identifying natural enemies of CRM

The coccinellid ladybird *Stethorus* sp. and the predatory mite *Agistemus longisetus* were the two most abundant natural enemies associated with CRM (Table 3). In general the abundance of these two natural enemies and evidence of their presence increased in response to increasing CRM population (data not shown).

*Stethorus* sp. larvae were seen eating eggs and juveniles of CRM. The smaller *Stethorus* sp. larvae tended to consume CRM eggs and the larger larvae tended to consume the juveniles and adults. *Stethorus* sp. adults were seen eating juvenile and adult CRM. The steelblue ladybird *Halmus chalybeus* was found at Orchard 4 where the CRM population was always low. Larvae and adult *H. chalybeus* fed voraciously on all life stages of CRM when transferred to CRM infested lemons.

At orchards where there was a moderate-high population CRM, over 88% of the predatory mites found were *A. longisetus*. *Agistemus longisetus* was observed preying on CRM eggs, but not on other CRM life stages.

*Anystis* sp. was found at three of the four sites, but this species was not seen eating CRM. *Phytoseiulus persimilis* was found at Orchard 3 in February 2005 and was observed feeding on juvenile and adult CRM. *Amblyseius largoensis* was the most abundant predatory mite at Orchard 4 where the CRM population was low. *Amblyseius largoensis* were observed consuming CRM juveniles. After feeding on CRM, the gut within the translucent body of *A. largoensis* turned a red colour. *Amblyseius largoensis* was most likely preying on greenhouse thrips in Orchard 4, which were abundant on leaf samples. Only two *Typhlodromus caudiglans* were found and these were not observed feeding on CRM.

**TABLE 3: Summary of the natural enemies found on leaf samples in orchards between January 2004 and March 2005.**

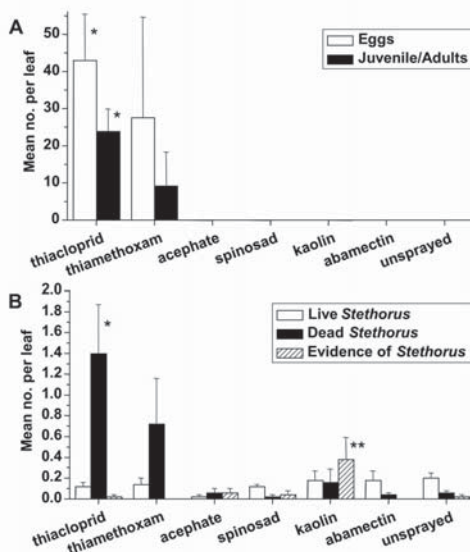
Orchard	Maximum average CRM per leaf (SEM)		Coccinellids	n	Predatory mites (% occurrence)
	Eggs	Juv/adult <sup>1</sup>			
1	313.1 (59.3)	62.3 (9.7)	<i>Stethorus</i> sp.	1033	99.4% <i>Agistemus longisetus</i> 0.6% <i>Anystis</i> sp.
2	24.0 (5.1)	1.7 (0.7)	<i>Stethorus</i> sp.	20	90% <i>Agistemus longisetus</i> 10% <i>Anystis</i> sp.
3	49.0 (4.6)	2.9 (1.3)	<i>Stethorus</i> sp.	148	87.8% <i>Agistemus longisetus</i> 8.1% <i>Phytoseiulus persimilis</i> 2.7% <i>Amblyseius largoensis</i> 1.4% <i>Typhlodromus caudiglans</i>
4	0.04 (0.02)	0.04 (0.02)	<i>Halmus chalybeus</i> <i>Stethorus</i> sp. <sup>2</sup>	171	97.7% <i>Amblyseius largoensis</i> 1.7% <i>Agistemus longisetus</i> 0.6% <i>Anystis</i> sp.

<sup>1</sup>Juv/adults = juveniles and adults combined.

<sup>2</sup>Evidence of *Stethorus* sp.

### Disrupting natural enemies of CRM

At Orchard 5, trees treated with the neonicotinoid thiacloprid had significantly more ( $P=0.03$ ) CRM eggs (average 43 per leaf) and juveniles/adults (average 21 per leaf) one month after the final spray application when compared to unsprayed trees and trees treated with acephate, spinosad, abamectin or kaolin (Fig. 1a). A significantly ( $P<0.001$ ) higher abundance of dead *Stethorus* sp. (average 1.4 per leaf) was also found on leaves treated with thiacloprid (Fig. 1b). However, the number of live *Stethorus* sp. was similar in all treated and untreated trees. *Stethorus* sp. adults are highly mobile and most likely redistributed themselves throughout the trial site by the time samples were taken. The number of CRM and dead *Stethorus* sp. tended to be higher in trees treated with the neonicotinoid CGA293343, but due to high variability this was not statistically different from the number of CRM and dead *Stethorus* sp. in any of the other treated or untreated trees. There was only one *A. longisetus* found on an abamectin-treated leaf.



**FIGURE 1:** Abundance of (a) CRM and (b) natural enemies at Orchard 5 in Te Puke in February 2004, one month after the application of insecticides to control Kelly’s citrus thrips. \* indicates significantly different ( $P<0.05$ ) from unsprayed and organophosphate, macrocyclic lactone, kaolin or avermectin treated trees for that particular series. \*\* indicates significantly different ( $P<0.05$ ) from all other treated and unsprayed trees for that particular series.

### Natural enemies reducing the abundance of CRM

The predators found at Orchard 6 were *Stethorus* sp., *A. longisetus*, *P. persimilis* and *A. largoensis*. *Agistemus longisetus* accounted for 273 of the 280 mites found. The population of CRM (15 eggs and 15 juvenile/adults per leaf) reduced to a ‘trace’ level over a period of 5 weeks in the presence of *Stethorus* sp. and primarily *A. longisetus* (Fig. 2). An average of ca 0.5 live *Stethorus* sp. per leaf was observed on the first and second sample and this was associated with ca one piece of *Stethorus* sp. evidence (moult, pupal case or egg case) per leaf being present on the second, third and fourth samples. An average of 0.5-1 *A. longisetus* per leaf was present in each sample.

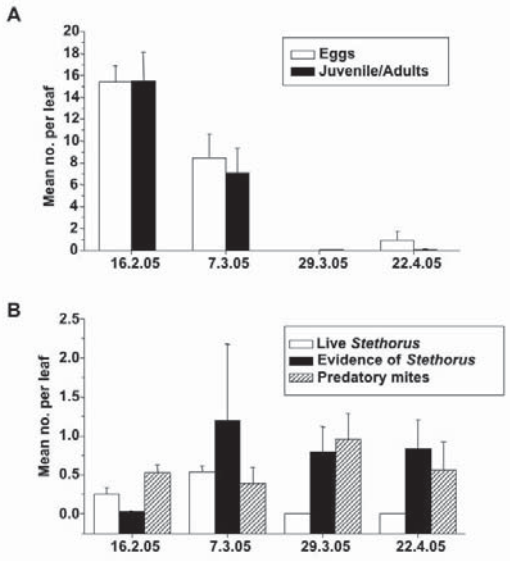


FIGURE 2: Abundance of (a) CRM and (b) natural enemies at Orchard 6 in Kerikeri from February until April 2005.

At Orchard 7 the reduction of a CRM population from 15 juvenile/adults per leaf to a 'non-detectable' level over four weeks was associated with *Stethorus* sp. (ca 0.5 per leaf) in combination with *A. longisetus* (ca 0.1 per leaf) (Fig. 3).

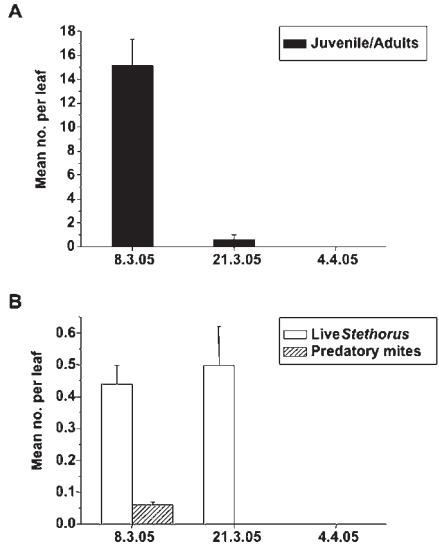


FIGURE 3: Abundance of (a) CRM and (b) natural enemies at Orchard 7 in Auckland from March until April 2005.

## DISCUSSION

The coccinellid ladybird *Stethorus* sp. and the stigmatid mite *A. longisetus* were the most abundant natural enemies found in association with CRM populations. *Stethorus* sp. was observed consuming all stages of this spider mite. Overseas it has been reported that a single *Stethorus punctum* adult can kill 41 CRM/day (Lui 2002) or 9 CRM/h (Hull 1995), so they may be highly effective at reducing moderate to high populations of CRM. In this study an average of 0.5 live *Stethorus* sp. per leaf in combination with 0.1-1 *A. longisetus* per leaf was associated with the reduction of a high population of CRM (15 eggs and 15 juveniles/adults per leaf) to a 'trace' or 'non-detectable' level over 4-5 weeks. The ability of *Stethorus* sp. to regulate CRM populations at low densities has been questioned (McMurtry 1985). However, in this study the presence of *Stethorus* sp. moults at an orchard where only an extremely low abundance of CRM were found, suggests that their rapid dispersal and efficiency in searching for prey enables *Stethorus* sp. to regulate CRM at low population densities. Peterson & McGregor (2000) reported that when prey density increased *Stethorus bifidus* became more efficient killers as their feeding time reduced and they did not consume as much of their prey as when prey numbers were lower.

*Agistemus longisetus* were only observed feeding on CRM eggs. Overseas studies show that mites of two different *Agistemus* species also prefer CRM eggs (Inoue & Tanaka 1983; Yue & Tsai 1995). The rates of natural increase of other *Agistemus* species overseas are reported to be very similar to CRM, therefore it has been suggested that although the *Agistemus* species are, in many situations, able to suppress CRM populations, they are less efficient than other predatory mites. The efficiency of *A. longisetus* in suppressing CRM populations has not been investigated. Evidence in New Zealand citrus orchards where *A. longisetus* and *Stethorus* sp. are usually found together, suggests that their different feeding preferences may be complementary and effective population regulation of CRM may require both species of predators. This has been shown in other scenarios with multiple predators against CRM (Tian 1995).

The phytoseiid mites, *A. largoensis* and *P. persimilis*, were found in low-moderate abundance on a few occasions when CRM were present. Because of their relatively small size, phytoseiid mites can survive on small populations of prey and achieve regulation at low host densities (DeBach & Rosen 1991). *Amblyseius largoensis* were observed feeding only on juvenile CRM and this is supported by overseas research whereby other *Amblyseius* species preferentially feed on juvenile CRM and occasionally on adult CRM but not generally on eggs (DeBach & Rosen 1991).

The anystid mite *Anystis* sp. and the phytoseiid mite *T. caudiglans* were found in very low abundance, were not observed feeding on CRM, and therefore are not considered major predators of CRM. Although the steelblue ladybird fed voraciously on all life stages of CRM when presented with this prey, it was not found associated with CRM on leaves and is not considered a major predator of CRM.

Future research should focus on the predation rates of *Stethorus* sp. and *A. longisetus* on CRM and the relative importance of these two predators. In the interim, the use of pesticides that are toxic to *Stethorus* sp., such as the neonicotinoids tested in this study, and *A. longisetus* should be minimised to avoid CRM outbreaks in New Zealand citrus orchards.

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