The efficacy of insecticides against Australian citrus whitefly (*Orchamoplatus citri*)

L.E. Jamieson, N.E.M Page-Weir, A. Chhagan and C. Curtis

*The New Zealand Institute for Plant & Food Research Limited (Plant & Food Research),
Private Bag 92169, Auckland*

Corresponding author: Lisa.Jamieson@plantandfood.co.nz

Abstract Australian citrus whitefly (ACWF) was first detected in Auckland in 2000 and has since spread to Kerikeri, Gisborne and Bay of Plenty, where it is causing sooty mould on a range of citrus varieties. Although classical biological control is being considered for long-term management of this pest, insecticidal control is required in the short term. In a laboratory bioassay, crawlers and young nymphs were the most susceptible life stages to insecticides, while pupae and eggs were very tolerant. Foliar applications of 11 insecticides and one soil-applied insecticide were tested in a potted plant trial targeting crawlers and young nymphs. Ten weeks after application, diazinon, endosulfan and a soil application of imidacloprid had reduced infestations to nil. Other effective products after 12 weeks were bifenthrin, spirotetramat, pyrethrin, buprofezin, azadirachtin, maldison, pyriproxifen and mineral oil. Foliar applications of pymetrozine, avermectin or soap did not significantly reduce numbers of ACWF compared with untreated plants at 12 weeks after application.

Keywords *Orchamoplatus citri*, Australian citrus whitefly, insecticides, life stage tolerance.

INTRODUCTION

Australian citrus whitefly (ACWF) (*Orchamoplatus citri*) was first detected in New Zealand in 2000 (Gill 2001). It has now spread from Auckland to all of the main citrus growing regions where it is causing significant sooty mould problems in backyard and commercial citrus, resulting in the downgrading of up to 90% of mandarin and orange crops (Pyle 2009) and possible tree health issues. All varieties of citrus are susceptible to ACWF infestation (Gill 2001).

ACWF infests the undersides of citrus leaves where the feeding adults and nymphs produce honeydew on which sooty mould grows. ACWF overwinter as immature nymphs and emerge as

adults in spring (Jamieson et al. 2009a). Adults move on to the young leaves to lay eggs from which crawlers emerge and develop through their nymphal stages over summer. There is one main generation per year, although in some orchards there is a small emergence of adults in autumn. Most late instars and pupae overwinter until the following spring.

ACWF arrived in New Zealand without effective natural enemies (Jamieson et al. 2009b), which are thought to limit ACWF populations in its native Australia (Vigianni & Carver 1988; Carver & Reid 1996) where it is a minor pest on citrus in some orchards only and rarely seen in

others (Russell 1958; Smith et al. 1997). Biological control has been successful for a range of whitefly species (van Lenteren et al. 1996; van den Berg et al. 2000; Liotta et al. 2003; Goolsby et al. 2004) and classical biocontrol has been identified as a long-term control strategy for this pest. However, effective insecticidal control combined with cultural strategies, i.e. pruning for an open canopy, are currently the only control options available.

There are no products with specific label claims against ACWF in citrus. Applications of endosulfan, pymetrozine, acephate or diazinon, which have label claims against other citrus pests, have reportedly reduced ACWF populations in the short term, with subsequent reductions in sooty mould rejection rates (Pyle 2009).

It is important to time insecticide applications to target the most susceptible life stage. These studies report on the relative susceptibility of different ACWF life stages to insecticides in laboratory leaf bioassay trials and the efficacy of insecticides against the most susceptible life stage on potted plants.

METHODS

Leaf bioassays

The relative susceptibility of different life stages of ACWF to different groups of insecticides was investigated using citrus leaves infested with pupae, adults/egg, crawlers or nymphs collected from unsprayed orchards in Auckland between October 2007 and January 2008 (different life stages tested each time). Leaf sections with either approximately 150 late pupae (with eyespots), 100 eggs (unknown age), 50 crawlers or 90 young (first/second instar) nymphs were cut and placed in Petri dishes lined with moistened filter paper. One of the following treatments was applied to both sides of the leaf (2 ml each side) using a Potter spray tower at 12 psi the day after the leaves had been collected: untreated control; pymetrozine (Chess® WG at 40 g/100 litres, a.i. 20 g/100 litres); buprofezin (Ovation™ 50WDG at 25 g/100 litres, a.i. 12.5 g/100 litres); mineral oil (Ultrafine oil at 1 litre/100 litres, a.i. 988 g/100 litres); endosulfan (Thiodan® at 200 ml/100

litres, a.i. 70 g/100 litres); pyrethrin (PyGanic® at 100 ml/100 litres, a.i. 13 g/100 litres); bifenthrin (Talstar 80SC at 20 ml/100 litres, a.i. 1.6 g/100 litres); spiromesifen (Oberon® at 60 ml/100 litres, a.i. 14.4 g/100 litres); or soap (Cold Water Surf® at 100 g/100 litres). These products and rates were selected based on literature pertaining to control of sucking insects, except for soap, which organic growers had observed to have good knock-down effect on various insect populations.

The residual toxicity of insecticides against adults was tested by treating uninfested leaves with one of the above treatments and once dry, transferring 10 adults (anesthetised with CO₂ in order to handle without injury) on to the treated leaf surface in a Petri dish lined with filter paper.

All Petri dishes were sealed with Parafilm® and each treatment was replicated four to five times. All insects were stored at 23°C and survival/mortality assessed at various intervals from 1 to 15 days after treatment. Pupae and nymphs were recorded as live if they were clear or yellow in colour and looked moist and turgid. Those that were discoloured brown or looked dry were recorded as dead. Empty pupal cases were recorded as live (emerged adults). Eggs were recorded as un-hatched if still entire, or hatched if split open. Crawlers were recorded as live if mobile and dead if immobile when prodded with a fine brush.

Potted plant bioassays

This bioassay tested 12 insecticides against crawlers and early nymphs (the most susceptible life stage of ACWF as determined by the leaf bioassay). In October 2008, potted Navel orange plants were moved into a glasshouse cubicle that contained a colony of ACWF. By 3 November 2008, a minimum of five new leaves on each plant had freshly laid ACWF eggs on them. Plants were moved into a shade-house and treated on 27 November 2008 when approximately 80% of crawlers had emerged (Table 1). Treatments were: untreated control; mineral oil (Excel® oil at 1000 ml/100 litres, a.i. 832 g/100 litres); buprofezin (Ovation™ at 25 ml/100 litres, a.i. 12.5 g/100 litres + oil at 500 ml/100 litres,

a.i. 416 g/100 litres); pymetrozine (Chess® at 40 g/100 litres, a.i. 20 g/100 litres); diazinon (Diazinon 50W™ 500 at 100 ml/100 litres, a.i. 80 g/100 litres); avermectin (Avid® at 25 ml/100 litres, a.i. 0.45 g/100 litres + oil at 300 ml/100 litres, a.i. 250 g/100 litres); bifenthrin (Talstar® 100 EC at 20 ml/100 litres, a.i. 1.6 g/100 litres); azadirachtin (NeemAzal™ at 500 ml/100 litres, a.i. 5 g/100 litres); endosulfan (Thiodan® at 150 ml/100 litres, a.i. 52.5 g/100 litres); soap (Cold Water Surf® at 100 g/100 litres); spirotetramat (Movento® at 15 ml/100 litres, a.i. 3.36 g/100 litres); or pyrethrin (Pyradym® at 50 ml/100 litres, a.i. 1.4 g/100 litres + oil at 250 ml/100 litres, a.i. 83.2 g/100 litres).

Two litres of each treatment were made up and applied using a 5-litre hand sprayer, ensuring that each leaf on each plant was sprayed but that there was minimal spray run-off. A soil treatment of imidacloprid (Confidor®) applied as a soil drench at 0.1 ml/ 100 ml per tree was also tested.

A second group of older potted Navel orange plants was set up similarly and treated when 80% of crawlers had emerged. They were treated with either polyether modified polysiloxane (Agpro organosilicone at 100 ml/100 litres), malathion (Malathion 50EC at 150 ml/100 litres, a.i. 75 g/100 litres), or pyriproxifen (Admiral® at 50 ml/100 litres, a.i. 5 g/100 litres + oil 300 ml/100 litres, a.i. 250 g/100 litres) and compared with unsprayed plants of a similar age.

Three replicates (plants) of each treatment were set up. Trees were left outside for approximately 2 h to dry before the five tagged leaves on each tree were enclosed within a large mesh bag. The leaves were bagged with mesh to allow some light and air flow but to exclude any ACWF from laying further eggs on the leaves and also to reduce any risk of cross contamination with ACWF from other sprayed trees.

The number of live ACWF (nymphs, pupae and empty pupal cases (indicating emerged adults)) on each tagged leaf on each tree was assessed before spray application and then every fortnight thereafter for 12 weeks.

Statistical analyses

For the leaf bioassay data, the percentages of adults emerged from pupae, adult mortality, eggs hatched, and crawler and nymph mortalities were angular transformed and then compared amongst treatments using Analysis of Variance (ANOVA). For the potted plant bioassay, the numbers of live ACWF on each leaf for all treatments were compared using ANOVA as the data were normally distributed and did not require transformation before analysis. Least significant differences (LSDs) were calculated to separate treatments where the ANOVA demonstrated significant differences ($P < 0.05$). The analyses were performed using GenStat (version 10) ((PC/Windows XP) Copyright 2006, Lawes Agricultural Trust (Rothamsted Experimental Station)).

RESULTS

Leaf bioassays

Fewer ACWF eggs hatched 15 days after exposure to spiromesifen, buprofezin, bifenthrin, pymetrozine or soap than in the untreated control (Table 1).

There was significantly higher mortality of crawlers treated with bifenthrin, spiromesifen, pyrethrin, endosulfan, mineral oil or soap (80.8–100%) than of untreated crawlers (10.8%) at 14 days after treatment (Table 1). No crawlers settled as first instars after treatment with spiromesifen, bifenthrin, pyrethrin, endosulfan or mineral oil (data not shown). In contrast, an average of 77.3% of the untreated crawlers survived and settled. It was also noted after subjective observation that untreated leaf sections had more honeydew than the insecticide-treated leaf sections.

All insecticide treatments resulted in significantly higher mortality of settled first to second instar nymphs at 7 days after treatment compared with the untreated control (Table 1). Treatment with bifenthrin or soap was most efficacious against first to second instar nymphs, while endosulfan, pyrethrin, pymetrozine and mineral oil were moderately effective. Buprofezin and spiromesifen were the least effective treatments in this short bioassay.

Table 1 Mean Australian citrus whitefly egg hatch (%; 15 days after treatment) and mortality of crawlers (%; 14 days after treatment) and settled first-second instar nymphs (%; 7 days after treatment) after insecticide treatments.

Treatment	Egg hatch	Mortality of crawlers	Mortality of nymphs
control	88.5 ± 5.3 a ¹	10.8 ± 3.2 e	16.3 ± 3.9 d
pymetrozine	66.1 ± 12.5 bc	44.6 ± 15.4 d	57.2 ± 7.6 bc
buprofezin	62.1 ± 8.0 bc	46.9 ± 18.2 d	45.5 ± 9.7 c
mineral oil	78.7 ± 5.4 ab	81.6 ± 6.1 c	60.3 ± 6.7 bc
endosulfan	83.6 ± 7.4 ab	89.4 ± 3.0 bc	70.3 ± 6.4 b
pyrethrin	82.3 ± 2.9 ab	97.7 ± 1.1 ab	74.2 ± 2.1 b
bifenthrin	64.8 ± 7.1 bc	100 a	91.7 ± 1.7 a
spiromesifen	45.4 ± 4.3 c	100 a	45.6 ± 8.8 c
soap	69.9 ± 8.6 b	80.8 ± 12.5 ab	92.4 ± 1.7 a
P-value	0.004	<0.001	<0.001

¹Within a column, means followed by the same letter are not significantly different at P=0.05.

There was no significant difference in adult emergence from treated pupae and untreated pupae 7 days after treatment, indicating that pupae were unaffected by the insecticides tested (Table 2).

Mortality of adults on unsprayed leaf sections was 2.2% at 1 day after treatment, and rapidly increased to 32.3% and 80% 2 and 3 days after treatment, respectively (Table 2). This indicates that the bioassay conditions were not optimal for assessing the efficacy of insecticides against adults

after 2 days. All adults on endosulfan-treated leaf sections and 72.0-83.1% of adults on pyrethrin and bifenthrin-treated leaf sections were dead at 1 day after treatment. There was significantly higher mortality (>90%) in the pymetrozine, buprofezin, mineral oil, endosulfan, pyrethrin and bifenthrin-treated leaves than on untreated leaves at 2 days after treatment. An average of 64.6-83.6% of adults on spiromesifen and soap-treated leaf sections were dead 2 days after treatment.

Table 2 Mean Australian citrus whitefly adult emergence (%) at 7 days after treatment of pupae with insecticides and mean mortality of adults (%) at 1, 2 and 3 days after exposure to insecticide residues.

Treatment	Adult emergence from treated pupae	Mortality of adults after exposure to residues		
		1 day	2 days	3 days
control	74.1 ± 9.6	2.2 ± 2.2 f ¹	32.3 ± 10.3 c	80.0 ± 8.2 b
pymetrozine	52.6 ± 9.6	46.7 ± 5.3 c	94.7 ± 3.1 a	100 a
buprofezin	75.9 ± 8.0	22.5 ± 5.2 d	92.5 ± 7.5 a	100 a
mineral oil	78.9 ± 9.4	62.0 ± 7.0 c	90.9 ± 7.0 a	97.5 ± 2.5 a
endosulfan	64.5 ± 5.1	100 a	100 a	100 a
pyrethrin	84.7 ± 1.6	72.0 ± 7.1 b	97.7 ± 7.1 a	100 a
bifenthrin	73.4 ± 7.8	83.1 ± 5.5 b	100 a	100 a
spiromesifen	68.6 ± 9.5	8.6 ± 3.0 e	64.6 ± 12.0 b	95.0 ± 2.9 a
soap	69.3 ± 8.5	11.9 ± 2.2 de	83.6 ± 2.2 b	97.5 ± 2.5 a
P-value	not significant	<0.001	<0.001	0.014

¹Within a column, means followed by the same letter are not significantly different at P=0.05.

Potted plant bioassays

Before spray application, there were no significant differences between the numbers of nymphal ACWF on leaves on treated and untreated young trees (Table 3). At 4 weeks after spraying, leaves treated with spirotetramat, bifenthrin, endosulfan, diazinon, mineral oil, azadirachtin and buprofezin had significantly fewer live ACWF than the untreated leaves (Table 3). By 6 weeks after treatment, leaves on young trees sprayed with the above products still had significantly fewer live ACWF than the untreated leaves. Pyrethrin-treated leaves and leaves on trees that received an imidacloprid soil drench also had significantly fewer ACWF than untreated leaves.

At 12 weeks post-spray, no live ACWF were found on the endosulfan, diazinon or imidacloprid-treated leaves. Application of bifenthrin, spirotetramat, pyrethrin, buprofezin, azadirachtin and mineral oil significantly reduced numbers of ACWF compared with those on untreated trees, with an average of 3-39 live ACWF per leaf on trees treated with these products (Table 3). Application of pymetrozine, avermectin or soap did not significantly reduce numbers of ACWF compared with numbers on untreated plants.

On the older trees there were significantly more ACWF on leaves assigned to the pyriproxifen treatment before spray application (Table 4). At 4 weeks after spraying, fewer live ACWF were found on leaves sprayed with organosilicone, malathion and pyriproxifen than on unsprayed leaves. By 12 weeks the numbers of ACWF on leaves treated with organosilicone were no different from the control, while those leaves sprayed with malathion and pyriproxifen has significantly fewer ACWF on them.

DISCUSSION

Results from the single leaf bioassays showed that the crawlers and young nymphs were the most susceptible life stages to the insecticides tested, and should be the primary target for insecticide sprays in the orchard. In Northland and Auckland there is one main generation of ACWF per year and a partial second generation (Jamieson et al. 2009a).

Crawlers and settled first/second instar nymphs are most abundant between mid November and mid January in these areas, and applications should be timed accordingly, following scouting activities to confirm that spraying is warranted and the presence of susceptible life stages.

Pupae and eggs were very tolerant to insecticides, therefore targeting these life stages (e.g. winter application targeting pupae) is not recommended. It was difficult to determine the relative susceptibility of adults to the insecticides in the leaf bioassays because of poor survival of individuals at 3 days after treatment. This poor adult survival after 3 days is not a function of a naturally short adult life stage, as observations in glasshouses suggest that adults live for about 3-4 weeks (L.E Jamieson, unpublished observations). This is consistent with observations on other species, such as silver leaf whitefly (*Bemisia tabaci*) and greenhouse whitefly (*Trialeurodes vaporariorum*), which live for about 22 or 29 days at 21°C or 22°C (Hoddle 1999).

Bifenthrin, spiromesifen, pyrethrin, endosulfan, mineral oil and soap were the most effective insecticides tested against the crawler and early nymph stages in the laboratory bioassay. Although the single leaf laboratory bioassays provided valuable life stage tolerance information, it was an artificial environment and thus the information has limited application. The impact of insecticides must be assessed in assays that replicate natural conditions as closely as possible for a true evaluation of efficacy, and trials should be carried out over an extended period to monitor their full effects and residual activity. This was achieved using potted plants and targeting crawlers and early nymph stages.

Treatment of potted plants infested with ACWF crawlers and settled young nymphs with endosulfan, diazinon, malathion, bifenthrin, spirotetramat, pyrethrin, buprofezin, pyriproxifen, azadirachtin or mineral oil gave good control of ACWF on potted plants for up to 12 weeks. Imidacloprid applied as a soil drench was also effective against ACWF for 6-12 weeks after application.

Endosulfan is no longer available because of a

Table 3 The mean ($\pm$ SEM) numbers of Australian citrus whitefly (nymphs, pupae and empty pupal cases (emerged adult)) per leaf on younger trees before spray (pre-spray) and fortnightly up to 12 weeks following spray application.

Treatment	Pre-spray	Post-spray					
		2 weeks	4 weeks	6 weeks	8 weeks	10 weeks	12 weeks
control	139±22.8	87.1±13.7 abcd ¹	137.3±23.33 c	97.9±21.9 b	114±17.3 cd	93.6±19.1 bc	129.3±22.9 b
mineral oil	174.8±24.7	157.8±32.4 cde	35.3±19.1 a	32.5±24.1 a	28.9±21.2 a	31.3±24.7 ab	39.2±32.3 a
buprofezin	133.3±24.4	167.8±29.9 de	54.4±13.6 ab	4.9±2.5 a	6.1±2.6 a	7.2±3.7 a	9.7±4.3 a
pymetrozine	166±19.6	107.3±25.4 abcd	117.5±32.7 bc	117.9±30.6 b	154±32.4 d	106.7±16.9 c	122.3±26.4 b
diazinon	104±25.5	25.3±8.8 a	18±10.4 a	0 a	0 a	0 a	0 a
avermectin	206.7±36.9	143.7±28.7 bcde	129.1±27.1 c	130±28.9 b	86.7±20.2 bc	83.8±17.4 bc	112.5±20.3 b
bifenthrin	477.5±254.5	50.7±23.3 abc	7±3.5 a	3.9±2.8 a	5±3.8 a	3.1±2.2 a	3.47±2.4 a
azadirachtin	110.9±31.3	103.3±31.1 abcd	44±10.7 a	29±8.9 a	20.3±6.2 a	24.9±9.3 ab	20.3±5.9 a
endosulfan	86±16.2	20.5±5.4 a	10.1±2.9 a	0 a	0 a	0 a	0 a
soap	232.3±36.8	473±100.2 f	463.1±72.5 d	377.1±57.3 c	232.7±34.8 e	364.7±80.7 d	249.3±50.9 b
spirotetramat	145.7±51	46±15.6 ab	3.7±1.5 a	3.3±2.2 a	3.8±2.2 a	5.2±3.0 a	3.6±2.3 a
pyrethrin	132.6±41.9	139.3±48.9 bcde	38.2±7.1 a	30.6±8.6 a	44.7±10.3 ab	34±8.8 ab	7.5±2.6 a
imidacloprid	139.3±36.2	219.3±41.7 e	74.1±17.9 abc	5.7±3.4 a	2±1.5 a	0 a	0 a
P-value	not significant	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

¹Within a column, means followed by the same letter are not significantly different at P=0.05.**Table 4** The mean ($\pm$ SEM) numbers of Australian citrus whitefly (nymphs, pupae and empty pupal cases (emerged adult)) per leaf on older trees before spray (pre-spray) and fortnightly up to 12 weeks following spray application.

Treatment	Pre-spray	Post-spray					
		2 weeks	4 weeks	6 weeks	8 weeks	10 weeks	12 weeks
control	297.9±39.6a ¹	235.7±38.9a	271.3±76.3b	186.3±36.5b	149.4±36.9b	122.2±31.2b	113.8±23.4b
organosilicone	404.7±24.1a	264.7±32.6a	87.3±22.1a	324.2±85c	206.9±46.3 b	175±47.1b	124.6±31.7b
maldison	403.5±114.4a	207.7±44.3a	0.7±0.7a	11.5±5.5a	1.8±1.2a	1.3±0.9a	1.4±1.4a
pyriproxifen	927.3±216.7b	678±119.3b	18.3±9.2a	94.5±30.1ab	28±11.3a	14.5±5.1a	22.6±8.4a
P-value	0.003	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

¹Within a column, means followed by the same letter are not significantly different at P=0.05.

recent Environmental Risk Management Authority (ERMA 2009a) review and diazinon is on the ERMA Chief Executive-Initiated Reassessment (CEIR) priority list of hazardous substances for reassessment (ERMA 2009b); therefore the future of diazinon-based insecticides is uncertain. Bifenthrin may have adverse repercussions by disrupting populations of natural enemies, such as *Stethorus* sp. ladybird and steel-blue ladybird, effective natural enemies of citrus red mites and scale insects respectively (Lo & Chapman 2001; Jamieson et al. 2005, 2008). Pyrethrin and pyriproxifen also have known side-effects against natural enemies (Robb et al. 2004) and their non-target impacts should be tested prior to their use in a citrus integrated pest management (IPM) programme.

Given that there are many records of insecticide resistance in whitefly species, it is important to have a variety of insecticides available for rotation within a resistance management strategy. The present findings indicate that there are several effective insecticides available for ACWF control that could be used within such a spray programme.

Good spray coverage is essential for the foliar applications of contact insecticides to be effective. ACWF populations are located on the underside of citrus leaves and efficient targeting of sprays to these areas will be critical if the pest is to be controlled. Use of systemic materials would be advantageous if lethal concentrations can reach the leaves of infested, mature citrus trees.

Although insecticides will provide some level of interim control of ACWF, the most effective long-term strategy is most likely to be the implementation of a biological control programme. In the mean time, insecticides that are least likely to be disruptive to other control agents in a citrus IPM strategy may include foliar applications of spiromesifen, buprofezin, azadirachtin or mineral oil, or a soil drench of imidacloprid in late spring or early summer when the crawler and young nymph stages are most abundant.

ACKNOWLEDGEMENTS

Thanks to Manoharie Sandanayaka for assisting

with assessments, to Bob and Vivian Murray and Jan and Graeme Jamieson for allowing us to collect ACWF from their orchards, to Andrew Harty at Kerifresh for supply of plants, New Zealand Citrus Growers Inc. and The New Zealand Foundation for Research, Science and Technology under (Contract CO6X0801) for funding this research.

REFERENCES

- Carver M, Reid IA 1996. Aleyrodidae (Hemiptera: Sternorrhyncha) of Australia. Systematic catalogue, host plant spectra, distribution, natural enemies and biological control. CSIRO Division of Entomology, Technical Paper No. 37. CSIRO, Canberra, Australia. 55 p.
- ERMA 2009a. Endosulfan use prohibited in New Zealand. (ERMA website: <http://www.ermanz.govt.nz/news-events/focus/endosulfan/index.html>) (accessed 31 May 2010).
- ERMA 2009b. Evaluation sheet: Candidates for reassessment priority listing. <http://www.ermanz.govt.nz/consultations/ceir/j.pdf> (accessed 31 May 2010).
- Goolsby JA, De Barro PF, Kirk AA, Sutherst R, Canas L, Ciomperlik M, Ellsworth P, Gould J, Hoelmer KA, Naranjo SJ, Rose M, Roltch W, Ruiz R, Pickett C, Vacek D 2004. Post-release evaluation of the biological control of *Bemisia tabaci* biotype "B" in the U.S.A. and the development of predictive tools to guide introductions for other countries. *Biological Control* 32: 70-77.
- Gill G 2001. Citrus whitefly blows in. *Biosecurity Issue* 26 (15 March 2001): 19.
- Hoddle MS 1999. The biology and management of silverleaf whitefly, *Bemisia argentifolii* Bellows and Perring (Homoptera: Aleyrodidae) on greenhouse grown ornamentals. <http://biocontrol.ucr.edu/bemisia.html> (accessed 31 May 2010).
- Jamieson LE, Charles JG, Stevens PS, McKenna C, Bawden R 2005. Natural enemies of citrus red mite (*Panonychus citri*) in citrus orchards. *New Zealand Plant Protection* 58: 299-305.
- Jamieson LE, Chhagan A, Charles J 2008. Predation of citrus red mite (*Panonychus citri*)

- by *Stethorus* sp. and *Agistemus longisetus*. New Zealand Plant Protection 61: 317-321.
- Jamieson LE, Chhagan A, Curtis C 2009a. Seasonal phenology of Australian citrus whitefly (*Orchamoplatus citri*) in New Zealand. New Zealand Plant Protection 62: 69-75.
- Jamieson LE, Curtis C, Chhagan A, Thorpe S 2009b. A survey of natural enemies in New Zealand citrus orchards infested with *Orchamoplatus citri*. 3rd International Symposium of Biological Control of Arthropods, 8-13 February 2009, Christchurch, New Zealand. Pp. 567-568.
- Liotta G, Agro A, Pinto M 2003. Biological control in citrus groves in the last 50 years: three successful cases in Western Sicily. International Organization for Biological and Integrated Control of Noxious Animals and Plants (OIBC/OILB, Dijon, France) Bulletin OILB/SROOP 26 (6): 171-173.
- Lo PL, Chapman RB 2001. Predation by *Halmus chalybeus* (Coleoptera: Coccinellidae) on *Ceroplastes destructor* and *C. sinensis* (Hemiptera: Coccidae: Ceroplastinae) infesting citrus in Northland, New Zealand. Biocontrol Science and Technology 11: 57-66.
- Pyle K 2009. The current status and economic impact of Australian citrus whitefly on New Zealand citrus. Report to New Zealand Citrus Growers Inc., Pyle Orchards and Consulting, Katikati, Tauranga, New Zealand. 27 p.
- Robb K, Costa HS, Bethke JA, Parella MP 2004. UC IPM Pest Management Guidelines: Floriculture and Ornamental Nurseries. UC ANR Publication 3392, University of California, California, U.S.A.
- Russell LM 1958. *Orchamoplatus*. An Australasian genus (Homoptera: Aleyrodidae). Proceedings of the Hawaiian Entomological Society 16: 389-410.
- Smith D, Beattie GAC, Broadley R 1997. Citrus pests and their natural enemies: integrated pest management in Australia. Queensland Department of Primary Industries, Brisbane, Australia. 272 p.
- van den Berg MA, Hoppner G, Greenland J 2000. An economic study of the biological control of the spiny blackfly, *Aleurocanthus spineferus* (Hemiptera: Aleyrodidae), in a citrus orchard in Swaziland. Biocontrol Science and Technology 10: 27-32.
- van Lenteren JC, van Roermund HJW, Sutterlin S 1996. Biological control of greenhouse whitefly (*Trialeurodes vaporariorum*) with the parasitoid *Encarsia formosa*: how does it work? Biological Control 6: 1-10.
- Vigianni G, Carver M 1988. *Cales orchamoplatus* sp. n. (Hymenoptera: Aphelinidae) from Australia. Journal of Australian Entomological Society 27: 43-45.