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Potato/tomato psyllid in New Zealand: immediate options for biological control

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Contents

1 Executive summary

The potato/tomato psyllid (*Bactericera cockerelli* (Hemiptera, Triozidae)) is a new invasive species in New Zealand, attacking solanaceous crops including tomatoes, capsicums and eggplants. This new pest is disruptive of IPM programmes used in greenhouse crops, as it is difficult to control with insecticides compatible with the biological control of whitefly, thrips and two-spotted mite.

Growers require information on insecticides and biocontrol agents that might be quickly developed for management of this insect in New Zealand.

1.1 Project objectives

Identify insecticides and biocontrol agents that could be used in the near future for control of the potato/tomato psyllid in covered crops in New Zealand

1.2 Project proposal

1.2.1 Insecticides

Undertake a literature and internet review on insecticides that might be used for potato/tomato psyllid control in covered crops in New Zealand and provide recommendations on efficacy, registration issues, and compatibility with current IPM programmes. This insecticide information is contained in a separate report: Crop & Food Research Confidential Report no. 1830.

1.2.2 Biocontrol agents

Undertake a literature and internet review to determine the range of psyllid species and their natural enemies (predators, parasitoids, pathogens) found in New Zealand and indicate whether any natural enemies could be used for biocontrol of the potato/tomato psyllid in covered crops.

1.3 Results

1.3.1 Predators and parasitoids

- The potato/tomato psyllid (genus *Bactericera*) is in the family Triozidae. In New Zealand there are an additional 33 species in this family, all in the genus *Trioza*. Analysis of the evolutionary relationships between these two genera suggests that they are closely related.
- Seven predators and two parasitoids of *Trioza* are recorded in New Zealand. Another predator that occurs in New Zealand has been reported attacking a *Trioza* species overseas.

- As the genus *Bactericera* is closely related to the genus *Trioza* it is possible that natural enemies of *Trioza* in New Zealand may be effective biological control agents for the potato/tomato psyllid.
- Several natural enemies of psyllids present in New Zealand deserve further investigation for their effectiveness to control potato/tomato psyllid under greenhouse conditions, including the predatory mirid *Sejanus albisignata*, the lacewing *Drepanacra binocular*, the parasitoid wasp *Tamarixia* sp and a number of ladybird species.
- Several entomopathogenic fungi (pathogens) have been isolated from psyllid species worldwide but there is limited information on their effectiveness under field conditions. *Beauveria bassiana* is thought to be more effective than other psyllid pathogens. This fungus is commercially available in New Zealand and is a promising candidate for control of the potato/tomato psyllid in covered crops.

2 Background

The potato/tomato psyllid (*Bactericera cockerelli* (Hemiptera, Triozidae)) is a new invasive species in New Zealand, attacking solanaceous crops including tomatoes, capsicums and eggplants. This new pest is disruptive of IPM programmes used in greenhouse crops, as it is difficult to control with insecticides compatible with the biological control of whitefly, thrips and two-spotted mite.

Growers require information on insecticides and biocontrol agents that might be quickly developed for control of this insect in New Zealand.

2.1 Project objectives

Identify insecticides and biocontrol agents that could be used in the near future for control of the potato/tomato psyllid in covered crops in New Zealand.

2.2 Project proposal

Insecticides. Undertake a literature and internet review on insecticides that might be used for potato/tomato psyllid control in covered crops in New Zealand and provide recommendations on efficacy, registration issues, and compatibility with current IPM programmes. That review has been completed as Crop & Food Research Confidential Report no. 1830: a companion to this report.

Biocontrol agents. Undertake a literature and internet review to determine the range of psyllid species and their natural enemies (predators, parasitoids, etc) found in New Zealand and indicate whether any natural enemies could be used for biocontrol of the potato/tomato psyllid in covered crops.

If suitable natural enemies are identified in New Zealand, a follow-up project to collect them and to establish rearing methods would be required. This may be completed in the SFF project given suitable timing.

This report identifies biological control agents (predators, parasitoids and pathogens) via a literature and internet review that could be used in the near future for control of potato/tomato psyllids in covered crops in New Zealand. It provides a list of natural enemies of New Zealand psyllids that have been reported and makes recommendations on which of these natural enemies may be suitable to develop as biological control agents in New Zealand.

3 Methods

Knowledge of the New Zealand psyllid fauna and its natural enemies will help identify potential biological control agents for the potato/tomato psyllid.

We carried out an extensive literature search (Web of Knowledge) and internet search (www.google.com) to establish:

(1) The number and biosystematic status of psyllid species in New Zealand. The evolutionary relationship of psyllid species in New Zealand with the potato/tomato psyllid (which originates from North America) is important as closely related species often share similar natural enemies.

(2) The natural enemies (predators, parasitoids and pathogens) of psyllids in New Zealand.

Additionally, the expert on New Zealand psyllids, Pam Dale (Auckland) was consulted. She provided a copy of an unpublished book chapter (P Dale, unpublished data). We also consulted her thesis (Dale 1985).

Additional information was provided by preliminary surveys of psyllid natural enemies in Auckland by Peter Workman as part of an internal funded Crop & Food Research project.

4 Results

4.1 The potato/tomato psyllid and its relatives in New Zealand

Psyllids belong to the superfamily Psylloidea, which comprises six families of which four are found in New Zealand (Psyllidae, Calophyidae, Homotomidae, Triozidae). The Triozidae has 34 species in New Zealand, all belonging to the genus *Trioza* except for the potato/tomato psyllid, which is in the genus *Bactericera*. All but two of the Triozidae species are indigenous to New Zealand. One New Zealand *Trioza* species (*T. vitreoradiata*) has become a nursery pest of its New Zealand host plant, *Pittosporum,* in the United Kingdom and Ireland (Martin & Malumphy 1995, O'Connor et al. 2004).

Based on morphological evidence, the genera *Bactericera* and *Trioza* are closely related (White & Hodkinson 1985). Molecular studies are required to clarify relationships between these genera, but evidence suggests that they are closely related, so some biological control agents may be effective for species in both genera.

4.2 New Zealand psyllids and their predators and parasitoids

Table 1 lists the known and potential natural enemies of psyllids recorded from published and unpublished information in New Zealand. It also includes recent observations made by Peter Workman of *T. vitreoradiata* natural enemies on *Pittosporum crassifolium* in New Zealand. To date, eight predators and two parasitoids have been recorded associated with *Trioza* in New Zealand. In addition, two other parasitoids have been reported from species in the family Psyllidae.

Hymenoptera

Parasitoid wasps

***Tamarixia* sp. (Hymenoptera: Eulophidae)**

An unidentified *Tamarixia* species has recently been found in New Zealand attacking the acmena psyllid (*Trioza eugeniae*) (J. Berry, pers. comm.). This *Tamarixia* species has also been found to parasitise the pittosporum psyllid (*Trioza vitreoradiata*) (J Berry, pers. comm.). Another species, *Tamarixia triozae,* has been successfully used to control potato psyllid in greenhouse capsicums in Canada (Elmhirst 2005). Initial tests indicate that the species of *Tamarixia* found in New Zealand was not able to parasitise the potato/tomato psyllid in the laboratory, but this requires further testing.

***Metaphycus* (Hymenoptera: Encyridae)**

Six species of *Metaphycus* are described from New Zealand but these do not include *M. psyllidus*, the species known to attack the potato/tomato psyllids.

***Adelencyrtoides variabilis* Noyes (Hymenoptera: Encyridae)**

This parasitoid attacks a variety of scale insects (www.landcareresearch.co.nz/ research/ biosystematics/invertebrates/softscales/fauna/parasit.asp) and has also been found to parasitise a native New Zealand psyllid, *Trioza irregularis,* which attacks a number of species of *Nothophagus* (P Dale, unpublished data).

4.3 Coleoptera

Coccinellidae

***Cleobora mellyi* L. (Coleoptera: Coccinellidae)**

The southern ladybird *Cleobora mellyi* is known to feed on psyllids (Table 2) and tortoise beetles (Cameron et al. 1989). It was introduced to New Zealand in 1977 for control of the eucalypt tortoise beetle *Parapsis charybdis*, but only

established in the Marlborough Sounds (www.nzffa.org.nz/ Eucalypt pest control/Cleobora.html). Since the introduction of *C. mellyi*, a number of psyllid species have established on eucalypts in New Zealand extending the range of prey available to this ladybird, and initiatives are underway to increase the distribution of *C. mellyi* in eucalypt plantings. A laboratory rearing method for rearing *C. mellyi* has been established (Bain et al. 1984).

Adalia bipunctata (Boisduval) (Coleoptera: Coccinellidae)

The two-spotted ladybird, *Adalia bipunctata*, is a European ladybird, but it is not known when it became established in New Zealand. It feeds on a range of insects, but has a preference for aphids and mealy bugs. It also feeds on acacia psyllids (P Dale, unpublished data). It was the most common ladybird found in association with the pittosporum psyllid, *Triozoa vitreoradiata*, and has been observed feeding on this psyllid in the laboratory (P Workman, unpublished data).

***Harmonia conformis* (Boisduval) (Coleoptera: Coccinellidae)**

The large spotted ladybird, *Harmonia conformis,* is a large orange ladybird with 23 black spots. It is Australian in origin and was introduced to New Zealand in 1896 (Cameron 1989). It is a general predator of aphids but also feeds on acacia psyllids (P Dale, unpublished data). This ladybird has also been observed feeding on the pittosporum psyllid but is found less frequently on this host than the two-spotted ladybird (P Workman, unpublished data).

***Halmus chalybeus* Boisduval (Coleoptera: Coccinellidae)**

The steelblue ladybird *Halmus chalybeus*, was introduced from Australia in 1899 (Cameron 1989) for the control of scale on eucalypts. It has also been recorded feeding on citrus red scale and San Jose scale (Lo 2000). The steelblue ladybird has also been found to feed on the acacia and pittosporum psyllids (P Dale, unpublished data).

Hemiptera

***Sejanus albisignata* (Knight) (Hemiptera: Miridae)**

Sejanus albisignata is a predatory mirid of Australasian distribution that was previously known as *Idatiella albisignata. Seganus albisignata* is a generalist feeding on a range of insects including aphids, lepidopteron eggs and small larvae of the pear midge, aphids, leafhoppers and psyllids (Eyles & Schuh 2003). It also feeds on an eriophyid mite that is found on the kaka bird's beak (Eyles & Schuh 2003). *Seganus albisignata* is often found on apple trees where it preys on European red mite, woolly aphids and codling moth eggs (Collyer & van Geldermalsen 1975). It also preys on psyllids found on acacia and ash (Dumbleton 1964). Recently it has been found to be an effective predator of pittosporum psyllid nymphs (P Workman, unpublished data). The number of generations varies from two in Otago to three in Auckland. The eggs are laid in the soft tissue of plant shoots. *Serganus albisignata* has five nymphal stages which are characteristically red in colour. Adults and nymphs have been collected from spring to autumn in all months from early October to late April and they overwinter as eggs (Wearing &

Attfield 2002). Although fruit damage by *S. albisignata* was reported by Scott & Daur (in Wearing & Attfield 2002) after caging the bugs with fruitlets, the practical and economic importance of this has yet to be demonstrated (Wearing & Attfield 2002). Another mirid, *Macrolophus caliginosus*, which is used to control greenhouse pests in Europe, has in some situations caused damage to crops such as cucumber, certain varieties of tomatoes, and gerbera (Malais & Ravensberg 2003). Tests would need to be undertaken to determine whether *S. albisignata* would cause crop damage before it could be used for the control of potato/tomato psyllids in greenhouse crops.

***Zanchius rubicrux* (Eyles) (Hemiptera: Miridae)**

This mirid is found throughout New Zealand and has been found in association with *Trioza adventicia* on *Syzygium australe* and with the pittosporum psyllid on *P. eugeniodies* (Eyles & Schuh 2003).

Neuroptera

***Drepanacra binocula* (Newman) (Neuoptera: Hemerobiidae)**

The hook-tipped lacewing, *Drepanacra binocula,* is an Australasian lacewing and is recorded in New Zealand feeding on pittosporum and acacia psyllids (Wise 1973). The sex of the adult *D. binocula* can be determined by differences in the shape of the wing (Wise 2000). Both the larvae and adults will feed on psyllids. *D. binocula* is reported to be the most important predator of psyllids on *Pittosporum* (Carter 1949). It was introduced to Hawaii to control *Acizzia uncatoides* on native acacia species (Leeper & Beardsley 1976). The larvae of *D. binocula* grow to be larger than the more common Tasmanian lacewing and are lighter in colour, with a white powdery covering. Recent studies indicate that *D. binocula* will feed on the potato/tomato psyllid (P Workman, unpublished data), but it is not known how this normally arboreal lacewing will adapt to greenhouse conditions. Previous studies indicated that when *D. binocula* were reared to adults in the laboratory they failed to produce eggs (Carter 1949). However, in recent studies no problems were encountered in achieving oviposition with laboratory-reared adult females given a diet of either pittosporum or potato/tomato psyllids (P Workman, unpublished data). Larvae of this lacewing have also been observed to feed on the adults and eggs of citrus whitefly and a native whitefly (N Martin, unpublished data). *D. binocula* is reported to be attacked by the parasitoid *Anacharis zealandica* (New 1982) but no parasitism has been observed in collections of this lacewing in November and December 2006 (P Workman, unpublished data). At this stage, *D. binocula* is the most promising lacewing candidate, because of its ability to feed on large numbers of potato/tomato psyllids.

***Micromus tasmaniae* Walker (Neuoptera: Hemerobiidae)**

The Tasmanian lacewing *Micromus tasmaniae* is well known for its ability to control aphids. It also feeds on pittosporum psyllid, but it is much less common on this host than is *D. binocula* (P Workman, unpublished data). Recent studies have shown that it will also feed on the potato/tomato psyllids but it is much less voracious than *D. binocula* (P. Workman, unpublished data.). There are established rearing methods for *M. tasmaniae* (P Workman,

unpublished data) and it has been considered as an aphid predator for greenhouse crops (P Workman, unpublished data). However it has a number of drawbacks including poor survival at temperatures over 25°C, a tendency to move off the plant during the day, specific oviposition requirements, and it is also attacked by the parasitoid *A. zealandica* (P Workman, unpublished data).

***Wesmaelius subnebulosus* (Stephens) (Neuoptera: Hemerobiidae)**

This lacewing species has been found to predate on pittosporum psyllid. *Boriomyia maorica* was thought to be endemic but, is now recognised as a widespread European species, *Wesmaelius subnebulosus*, which was unintentionally introduced (Wise 1995). This species also feeds on arboreal aphids. It was not found in a recent survey of natural enemies of pittosporum psyllid in 2006 (P Workman, unpublished data).

4.4 Pathogens

Entomopathogenic fungi play an important role in the regulation of insect pests. Several fungi have been isolated from field populations of different psyllids worldwide (Jaques & Patterson 1962, Arzone 1979, Samways & Grech 1986, Hsieh et al 1987, Liu et al 1990, van der Berg 1996, Moore 1996, Subandiyah et al 2000, Dhiman & Arora 2005). Natural epizootics of *Zoophthora radicans* (formerly *Entomophthora sphaerosperma*) effectively regulated the European apple sucker, *Psylla mali*, in Canada until the introduction and widespread use of synthetic fungicides inhibited the development and spread of this pathogen (Jaques & Patterson 1962). *Zoophthora radicans* and other entomphoralean fungi are difficult mass produce commercially. Most mycoinsecticides are based on Hyphomycete strains, which can be grown on a wide range of artificial substrates (Brownbridge 2006).

Few isolates have been fully evaluated for control of psyllid populations under field conditions. However, the fungus *Beauveria bassiana* is a common insect pathogen with a diverse host range and global distribution. It has been successfully used to control the pistachio psyllid *Agonoscena targionii* in Syria (Lababidi 2002) and the leucaena psyllid *Heteroosylla cubana* in the Philippines (Barrion et al. 1987). In a series of laboratory and greenhouse trials Al-Jabr (1999) demonstrated the potential of *B. bassiana* to control nymphs of the potato/tomato psyllid, giving between 86% and 96% mortality after 3 days. *Beauveria bassiana* and a range of other entomopathogenic fungi were also tested in laboratory bioassays against the pear psyllid, *Cacopsylla pyricola*, by Puterka et al. (1994). *Beavaria bassiana*, *Paecilomyces fumosoroseus* and *Verticillium lecanii* (= *Lecanicillium muscarium*) isolates all killed 100% of the exposed nymphs in 7 days. The best *B. bassiana* and *P. fumosoroseus* isolates were selected for further testing, alongside two commercial formulations based on *B. bassiana* (Mycotrol and Naturalis L). Psylla nymph mortality on pear trees reached as high as 63% after 9 days, following a single spray application of the *B. bassiana.* This result was better than either of the commercial preparations tested. The mortality resulting from application of Naturalis was attributed to effects of the oil carrier (Puterka 1999).

Beauveria bassiana has also been effectively used on other pests of protected crops such as whiteflies, thrips, aphids and two-spot spider mite (Jacobson et al. 2000, Faria & Wraight 2001, Alvilla et al. 2005, Hoddle 2005, Chandler et al. 2005, Brownbridge 2006). The fungus is available as a microbial pesticide from several producers overseas (most notably as Naturalis, BotaniGard, and Mycotrol in the US[1]) and in New Zealand (Beugenic, Crop Solutions Ltd[2]).

Another fungus that could potentially be used for control of the potato/tomato psyllid is *Lecanicillium muscarium* (formerly *Verticillium lecanii*). Like *B. bassiana*, *L. muscarium* has a wide host range and is successfully used to control a range of greenhouse pests including greenhouse and silverleaf whitefly (Negasi et al. 1998, Gindin et al. 2000, Wraight et al. 2000, Faria & Wraight 2001, Koike et al. 2004, Avilla et al. 2005, Cuthbertson & Walters 2005, Hoddle 2005), thrips (Butt & Brownbridge 1997), and various species of aphids (Hall & Burges 1979, Hall 1981, Fournier & Brodeur 2000, Blümell 2005) overseas. *Lecanicillium muscarium* (*V. lecanii*) has previously been isolated from the citrus psyllid *Diaphorina citri* in Cuba (Aragon & Ravelo 2000). Puterka et al. (1994) showed that the fungus was as effective as *B. bassiana* and *P. fumosoroseus* in laboratory trials against pear psylla but Al-Jabr (1999) found that *V. lecanii* was much less effective in controlling potato/tomato psyllids in greenhouse tomatoes than *B. bassiana.* Commercial mycoinsecticides based upon *V. lecanii* (still named as the active ingredient) are available from The Netherlands (Mycotal, Koppert Biological Systems), Mexico (Ago Biocontrol Verticillium, Ago Biocontrol Mexico) and England (Vertalec, Plant Solutions), and two formulations are produced and registered for greenhouse use in New Zealand (Vertoblast – *L. muscarium* blastospores; and Vertokill – *L. muscarium* conidia, two strains; Crop Solutions Ltd[2]).

[1] Although not registered for use in NZ, Mycotrol/BotaniGard and the GHA isolate on which these products are based is available for testing in containment facilities (AgResearch, Lincoln).
[2] Information from the company suggests that Beaugenic may be active against psyllids.

Table 1: Natural enemies of Trioza species recorded in New Zealand.

Psyllid family/species	Natural enemy	Comment	Reference
Triozidae			
Trioza adventicia	*Zanchius rubicrux* [Miridae]	Predator observed on *Syzygium australe* in association with *T. adventicia.*	Eyles (2005)
Trioza irregularis	*Adelencyrtoids variablis* [Encyrtidae]	Parasitoid	Valentine and Walker (1991), Dale (unpublished data)
Trioza vitreoradiata	*Adalia bipunctata* [Coccinellidae]	Ladybird predator found in association with *T. vitreoradiata* on *Pittosporum crassifolium*	Workman (personal obs.)
"	*Halmus (Orcus) chalybeus* [Coccinellidae]	Ladybird predator	Dale (unpublished data)
"	*Wesmaelius subnebulosa* [Hemerobiidae]	Lacewing predator	Dale (unpublished data)
"	*Drepanacra binocula* [Hemerobiidae]	Lacewing predator found in association with *T. vitreoradiata* on *Pittosporum crassifolium*	Dale (unpublished data) Workman (personal obs.)
"	*Micromus tasmaniae* [Hemerobiidae]	Lacewing predator found in association with *T. vitreoradiata* on *Pittosporum crassifolium*	Dale (unpublished data) Workman (personal obs.)
"	*Zanchius rubicrux* [Miridae]	Predator observed in large numbers on *Pittosporum eugenioides* in association with *T. vitreoradiata*	Eyles (2005)
"	*Sejanus albisignata* [Miridae]	Predator found in association with *T. vitreoradiata* on *Pittosporum crassifolium*	Workman (personal obs.)
"	*Tamarixia* sp. [Eulophidae]	Parasitoid reared from *T. vitreoradiata* on *Pittosporum crassifolium*	Workman (personal obs.)

Table 2: Natural enemies of non-Trioza species recorded in New Zealand.

Psyllid family/species	Natural enemy	Comment	Reference
Psyllidae			
Acizzia acaciae	*Adalia bipunctata* [Coccinellidae]	Ladybird predator	Dale (unpublished data)
"	*Cleobora mellyi* [Coccinellidae]	Ladybird predator	Dale (unpublished data)
"	*Harmonia conformis* [Coccinellidae]	Ladybird predator	Dale (unpublished data)
"	*Drepanacra binocula* [Hemerobiidae]	Lacewing predator	Dale (unpublished data)
Acizzia acaciaebaileyanae	*Cleobora mellyi* [Coccinellidae]	Ladybird predator	Dale (unpublished data)
"	*Psyllaephagus acaciae* [Encyrtidae]	Parasitoid	Hollis (2004)
Acizzia albizzae	*Drepanacra binocula* [Hemerobiidae]	Lacewing predator	Dale (unpublished data)
Acizzia exquisita	*Psyllaephagus acaciae* [Encyrtidae]	Parasitoid	Hollis (2004)
Acizzia uncatoides	*Adalia bipunctata* [Coccinellidae]	Ladybird predator	Dale (unpublished data)
"	*Cleobora mellyi* [Coccinellidae]	Ladybird predator	Dale (unpublished data)
"	*Harmonia conformis* [Coccinellidae]	Ladybird predator	Dale (unpublished data)
"	*Halmus (Orcus) chalybeus* [Coccinellidae]	Ladybird predator	Dale (unpublished data)
"	*Drepanacra binocula* [Hemerobiidae]	Lacewing predator	Dale (unpublished data)
Ccizia acaciae	*Halmus (Orcus) chalybeus* [Coccinellidae]	Labybird predator	Dale (unpublished data)
Ctenarytaina eucalypti	*Psyllaephagus pilosus* [Encyrtidae]	Parasitoid	Hollis (2004)
Psyllopsis fraxini	*Sejanus albisignata* [Miridae]	Predator	Dale (unpublished data)
Psyllopsis fraxinicola	*Sejanus albisignata* [Miridae]	Predator	Dale (unpublished data)

Additionally *Anystis baccarum* [Anystidae], which has been found in apple orchards in New Zealand (Collyer & van Geldermalsen 1975), has been reported as a predator of *Trioza erytreae*, and has been used to control mite pests on a shrub in South Africa (van der Berg et al 1995).

5 Discussion

5.1 Predators and parasitoids

Several natural enemies of psyllids present in New Zealand deserve further investigation for their effectiveness to control potato/tomato psyllid under greenhouse conditions. These include the predatory mirid *S. albisignata*, the lacewing *D. binocula*, and the parasitoid wasp T*amarixia* sp.

Sejanus albisignata is a voracious feeder of pittosporum psyllids, but its ability to feed on potato/tomato psyllid has yet to be determined. This mirid could be a useful natural enemy in greenhouse crops as it is generalist predator and may also feed on thrips mites and whitefly. This would enable populations of *S. albisignata* to become established in the greenhouse prior to infestations of potato/tomato psyllid. It is probable that *Sejanus* would go into diapause over the winter months.

The lacewing, *D. binocular* also shows promise as a predator of potato/tomato psyllid as it has been demonstrated that both the adult and larvae will feed on potato/tomato psyllids in the laboratory. This lacewing has also been observed feeding on the adults and eggs of citrus whitefly and a native whitefly. It is possible that it could feed on these stages of the greenhouse whitefly.

Although *S. albisignata* and *D. binocula* feed on potato/tomato psyllid, there is no guarantee that they will be effective predators in the greenhouse environments or on specific crops. As some predatory mirids also feed on plant sap, tests would be needed to find whether S. *albisignata* would cause plant damage on greenhouse crops.

Initial tests indicate that the species of *Tamariaxia* present in New Zealand was not able to parasitise the potato/tomato psyllid, but further work is required to confirm this.

There are a number of ladybirds that attack psyllids in New Zealand. The two-spotted ladybird *Adalia bipunctata* is the most abundant ladybird on the pittosporum psyllid. Another possible predator of potato/tomato psyllid is the southern ladybird *Cleobora mellyi*. Although it has yet to be shown that this ladybird will feed on potato/tomato psyllids, there is a published rearing method for this predator. Ladybirds are generally difficult to rear on a commercial scale.

The potato/tomato psyllid comes from North America where it is attacked by a range of natural enemies. However, only the parasitoid wasp *T. triozae* gives successful biological control of potato/tomato psyllids in greenhouse crops. Although *T. triozae* has been used successfully in capsicum crops it is less effective in tomatoes as it only attacks the 4th and 5th instar larvae, which is too late to prevent the damage caused by the toxin injection of the potato/tomato psyllid. *Tamariaxia triozae* attacks numerous psyllid genera and if it were to be imported into New Zealand, extensive testing would be

require to demonstrate that it would not cause an unacceptable threat to indigenous psyllids.

5.2 Pathogens

Entomopathogenic fungi have been recommended for the control of potato/tomato psyllid and other pest species in North America and have potential for use in their control in New Zealand. However, there have been few concerted efforts to evaluate species and strains that would be effective against potato/tomato psyllid, as well as defining the conditions required for infection and production of spores (necessary for recycling of the disease within the population), and optimising spray formulations, techniques and intervals for effective and economically viable control. A range of entomopathogenic fungi is available commercially both in New Zealand and overseas. As a starting point, some of these products should be evaluated for their ability to control potato/tomato psyllid under New Zealand greenhouse conditions. In the longer term, investment in a programme to assess other candidate strains from New Zealand seems justified. This will require an investigation to select the best candidate strain(s), and development of strategies to integrate their use with other crop management practices in greenhouse vegetables.

6 Acknowledgements

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