Natural enemies in Australian citrus

A fact sheet from the citrus industry IPDM extension program (CT19011)

Natural enemies are the parasitoids, predators, and pathogens that attack pests. The reduction of pests by natural enemies is known as biological control. Natural enemies are often referred to as 'beneficials' and are extremely important in citrus throughout the world. In Australia, over 80 species of insects and mites are known as potential pests (Smith et al. 1997). Most of these rarely cause economic damage because they are regulated by natural enemies and abiotic factors. Some of the natural enemies are endemic to Australia, but many have been purposefully introduced to lower the damage caused by pests and reduce the need for pesticide applications.

There is a long history of biological control in citrus following the spectacular success of introducing the predatory Vedalia beetle (*Rodolia cardinalis*, Figure 1) and *Cryptochaetum iceryae* (parasitoid fly) from Australia into California to save the young citrus industry from cottony cushion scale in 1889.

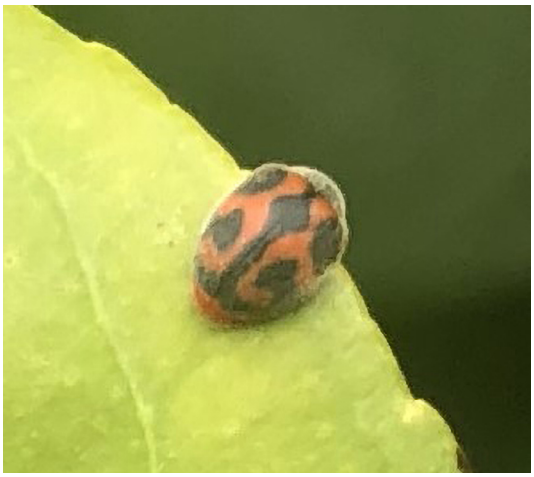

Figure 1. Vedalia beetle (*Rodolia cardinalis*). Photo: Rob Weppler.

Aphytis spp. are tiny yellow wasps that are very effective parasites of red scale (Figure 2). Monitoring data from a recent NSW DPI demonstration site at Griffith have shown *Aphytis* spp. to greatly reduce red scale infestation over a 2 month period in a common orange juice block. Predatory mites were also an active beneficial at the demonstration site. The reduction of pests by natural enemies at the site negated the need for an insecticide spray.

Parasitoids

Parasitoids of citrus pests are almost all wasps (Hymenoptera), but there are also some important parasitoid flies (Diptera). Parasitoids lay their eggs in or on the host pest. The parasitoid larvae then feed on the host, killing it, and emerge as an adult to repeat the process. A parasitoid only requires one host to complete its life cycle. Parasitoids usually only attack one to a few species of closely related pests. *Aphytis* spp. wasps (Figure 2) and *Trissolcus* spp. wasps (Figure 3) are examples of parasitoids common in Australian citrus orchards where the least disruptive insecticide options for pest control are used.

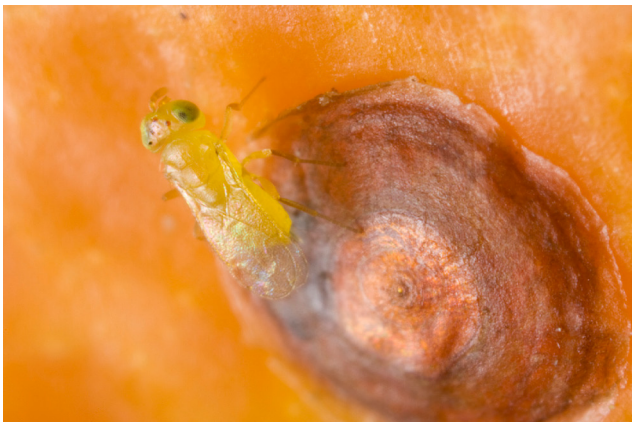

Figure 2. *Aphytis* spp. laying eggs in a red scale. Photo: Denis Crawford.

Figure 3. *Trissolcus* spp. emerging from spined citrus bug eggs. Photo: Rob Weppler.

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Predators

Predators require multiple individuals (prey) to complete their life cycle. There are many different types or groups of predators. The most important groups in citrus integrated pest management (IPM) are lacewings (Figure 4), predatory mites, and lady beetles.

Figure 4. Green lacewing larvae (left and middle) are active predators in citrus orchards where careful consideration is given to insecticide choices to conserve natural enemies. Green lacewing larvae disguise themselves with the exoskeleton of their prey and plant debris. Green lacewing adults (right) are most active during spring. Photo: Rob Weppler.

Cryptolaemus montrouzieri, also known as the mealybug destroyer (Figure 5), are available in Australia for augmented release. *Cryptolaemus montrouzieri* naturally occur in orchards where careful consideration is given to insecticide choices. Several other predator groups are also present in citrus orchards and can be important in controlling particular pests. Some predators will only attack a few species, but many are generalists and feed on a wide variety of pests. Generalist predators commonly seen in citrus orchards in southern Australia include jumping spiders (Figure 6) and the tiny two-spotted lady beetles (Figure 7). Robber flies, which eat anything they can catch, including pests and beneficial arthropods, are also often found.

Figure 5. The larvae (left) and adult (right) of *Cryptolaemus montrouzieri*, which are an Australian native lady beetle. Both the larvae and adults are active predators, feeding on mealy bugs and soft scales. The larvae look similar to mealybugs. Photos: Rob Weppler.

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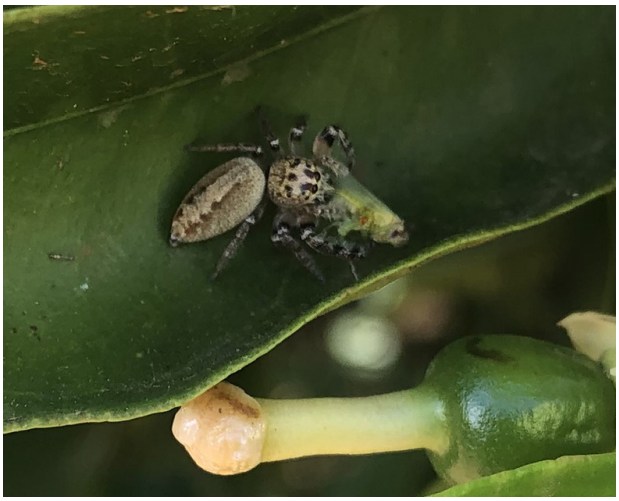

Figure 6. A jumping spider eating a leafhopper. Photo: Rob Weppler.

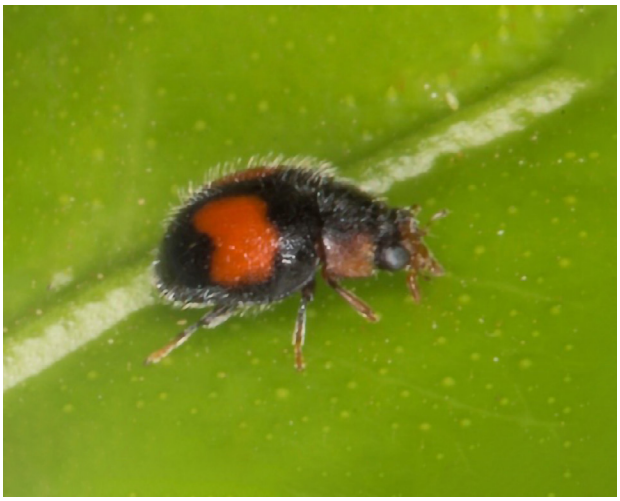

Figure 7. A two-spotted lady beetle (*Diomus notescens*).

Pathogens

Pathogens can also help control pests in citrus orchards, particularly in humid environments. Insect pathogens are mostly fungi, but parasitic nematodes are also considered pathogenic. While pathogens can be effective in reducing populations of red scale, Fuller's rose weevils, and whiteflies, they are usually less important in citrus than parasitoids and predators. Pathogens are not included in the tables here.

Considering beneficials when using pesticides

Most citrus orchards have many beneficial species (parasitoids and predators) that occur naturally and assist with pest management. Pesticide applications have an impact on the natural enemies. When choosing an insecticide, miticide or fungicide to control a specific pest, consider the toxicity of that chemical to the natural enemies you have in the orchard. Regular crop monitoring should include checking for both pests and natural enemies. Selecting a 'softer' chemical option to beneficials might prevent further chemical use to manage secondary pest flares resulting from the initial chemical application.

Table 1 lists the main generalist predators for citrus that feed on a variety of pests. Table 2 lists the main parasitoids (column 1) and predators (column 2) for common citrus pests. It is beyond the scope of this fact sheet to give information on each species, but with the scientific name, you can easily find more information on the internet. We have indicated the group to which the predators belong in brackets after their name and colour-coded the most important groups for use with Table 3 and Table 4, which list the pesticide toxicity ratings to natural enemies in the orchard.

Note 1: there is variation in susceptibility to insecticides among individual species within a group. When choosing an insecticide, aim to select the option that is least toxic to the natural enemies that are most important in your orchard by using Table 3 and Table 4. Sublethal effects are difficult to assess and are much less studied. Pesticides listed with low direct toxicity could still impact populations through unknown sublethal effects.

Note 2: this fact sheet does not include the group for parasitoids since most are wasps, and they can be considered together when using Table 3 and Table 4. However, most of the chemical toxicity data is from testing wasps.

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Table 1. Generalist predators for citrus that feed on a variety of pests.

Generalist predators	Group
Aelothrips spp.	Thrips
Anystis spp.	Mites
Asilidae	Robber flies
Haplothrips victoriensis	Thrips
Lycosidae	Wolf spiders
Mallada spp.	Green lacewing
Micromus spp.	Brown lacewing
Phytoseiid mites	Mites
Salticidae	Jumping spiders

Table 2. Parasitic wasps and flies and predators for common citrus pests.

Parasitic wasps and flies	Predators
Aphids	
Acroclisoides tectacorisi	*Coccinella transversalis* (lady beetles)
Anastatus biproruli	*Harmonia conformis* (lady beetles)
Aphelinus spp.	*Hippodamia convergens* (lady beetles)
Aphidius spp.	*Mallada* spp. (green lacewings)
Centrodora darwini	Mantodea (Praying mantids)
Tachinidae (flies)	*Pristhesancus plagipennis* (assassin bugs)
–	Salticidae (jumping spiders)
–	*Simosyrphus grandicornus* (syrphid flies)
Citrus gall wasp	
Megastigmus brevivalvus	–
Megastigmus trisulcus	–
Citrus leafminer	
Ageniaspis citricola	–
Cirrospilus ingenuus	–
Semielacher petiolata	–
Citrus whitefly	
Cales noacki	*Cybocephalus aleyrodiphagus* (Cybocephalidae)
Encarsia spp.	*Euseius victoriensis* (mites)
–	*Mallada* spp. (green lacewings)
Cottony cushion scale	
Cryptochaetum iceryae	*Cryptolaemus montrouzieri* (lady beetles)
–	*Rodolia* (Vedalia) *cardinalis* (lady beetles)
–	*Rodolia koebeli* (lady beetles)
Fuller's rose weevil	
Fidobia citri	–
Katydids	
Unknown parasitoids	Mantodea (praying mantids)
–	Salticidae (jumping spiders)
–	Sphecids (wasps)

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Parasitic wasps and flies	Predators
Light brown apple moth	
Dolichogenidea tasmanica	*Mallada* spp. (green lacewings)
Goniouzus spp.	*Oechalia schellenbergii* (shield bug)
Trichogramma spp.	Salticidae (jumping spiders)
Voriella spp.	–
Xanthopimpla rhopaloceros	–
Zosteromyia mima	–
Mealybugs	
Allotropa spp.	*Cryptolaemus montrouzieri* (lady beetles)
Anagyrus fusciventris	*Diadiplosis koebelei* (flies)
Anagyrus pseudococci	*Diomus notescens* (lady beetles)
Coccidoxenoides peregrinus	*Haplothrips victoriensis* (thrips)
Coccophagus gurneyi	*Mallada* spp. (green lacewings)
Coccophagus spp.	*Rhyzobius ruficollis* (lady beetles)
Leptomastidea abnormis	*Scymnus* spp. (lady beetles)
Leptomastix dactylopii	–
Ophelosia spp.	–
Tetracnemoidea brevicornis	–
Tetracnemoidea peregrina	–
Tetracnemoidea sydneyensis	–
Queensland fruit fly	
Diachasmimorpha tryoni	Salticidae (jumping spiders)
Fopius arisanus	–
Fopius deeralensis	–
Opius perkinsi	–
Red scale	
Aphytis melinus	*Anystis* spp. (mites)
Aphytis lignanensis	*Chilocorus circumdatus* (lady beetles)
Aphytis chrysomphali	*Euseius* spp. (mites)
Comperiella bifasciata	*Halmus chalybeus* (lady beetles)
Encarsia citrina	*Mallada* spp. (green lacewings)
Encarsia perniciosi	*Rhyzobious lophanthae* (lady beetles)
–	*Saniosulus nudus* (mites)
Rust mites	
–	*Amblyseius herbicolus* (mites)
–	*Amblyseius lentiginosus* (mites)
–	*Euseius elinae* (mites)
–	*Euseius victoriensis* (mites)
Soft scales	
Anicetus communis	*Catoblemma dubia* (caterpillars)
Anicetus nyasicus	*Cryptolaemus montrouzieri* (lady beetles)
Coccophagus lycimnia	*Diomus notescens* (lady beetles)
Coccophagus semicircularis	*Halmus chalybeus* (lady beetles)
Diversinervus elegans	*Harmonia conformis* (lady beetles)
Encyrtus aurantii	*Mallada* spp. (green lacewings)

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Parasitic wasps and flies	Predators
Soft scales continued	
Euryischomyia flavithorax	*Micraspis frenata* (lady beetles)
Metaphycus alberti	*Orcus australasiae* (lady beetles)
Metaphycus helvolus	*Rhyzobious lophanthae* (lady beetles)
Metaphycus inviscus	*Scymnodes lividigaster* (lady beetles)
Metaphycus lounsburyi	*Serangium bicolor* (lady beetles)
Metaphycus luteolus	–
Microterys flavus	–
Microterys triguttatus	–
Moranila californica	–
Scutellista caerulea	–
Two-spotted mites	
–	*Euseius elinae* (mites)
–	*Euseius victoriensis* (mites)
–	*Gallendromus occidentalis* (mites)
–	*Mallada* spp. (green lacewings)
–	*Phytoseiulus persimilis* (mites)
–	*Scolothrips sexmaculatus* (thrips)
–	*Stethorus* spp. (lady beetles)
Thrips	
–	*Aelothrips* spp. (thrips)
–	*Anystis* spp. (mites)
–	*Haplothrips victoriensis* (thrips)
–	*Mallada* spp. (green lacewings)
–	Phytoseiid mites (mites)

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Table 3. Insecticide toxicity ratings to natural enemies in the orchard, where 0 = none, 1 = very low, 2 = low, 3 = medium, 4 = high, and 5 = very high. There is variation in susceptibility to insecticides among individual species within a group, please refer to notes 1 and 2.

Active and (group)	Product example	Parasitic wasps 	Lacewings 	Lady beetles 	Predatory mites 
Acetamiprid + pyriproxyfen (4A + 7C)	Trivor®	4	2	4	2
Bacillus thuringiensis (Bt) (11A)	Dipel® DF	0	0	0	0
Buprofezin (16)	Applaud®	2	2	4	1
Carbaryl (1A)	Bugmaster® Flowable	5	4	5	5
Chlorpyrifos (1B)	Chlorpyrifos 500 EC	4	4	4	4
Clothianidin (4A) (soil applied*)	Samurai®	2	2	2	3
Cyantraniliprole (28)	Exirel®	2	3	3	2
Diazinon (1B)	Diazinon 800	4	4	4	4
Dimethoate (1B)	Dimethoate 400	5	5	5	4
E-11-tetradecen-1-yl acetate and e-9-e-11-tetradecadien-1-yl acetate	Splat LBAM	0	0	0	0
Imidacloprid (4A) (soil applied*)	Nuprid 350®	2	2	2	2
Malathion (1B)	Fyfanon 440 EW	4	4	4	3
Methomyl (1A)	Nufarm Methomyl 225	4	4	4	4
Methoxyfenozide (18)	Prodigy®	1	2	2	2
Omethoate (1B)	Folimat® 800 SL	5	5	5	5
Paraffinic oil	Biopest®, Bioclear®, Trump®	1	1	1	2
Permethrin (3A)	Ambush®	5	5	5	5
Petroleum oil	D-C-Tron®, Summer oil	1	1	1	2
Pirimicarb (1A)	Pirimor® WG	3	1	1	1
Pyrethrins (3A)	PyGanic®	3	3	3	3
Pyriproxyfen (7C)	Admiral® Advance	2	2	4	0
Spinetoram (5)	Success® Neo	5	3	1	4
Spinosad (5)	Entrust® Organic Insecticide	4	3	1	3
Spirotetramat (23)	Movento® 240 SC	1	1	1	4
Sulfoxaflor (4C)	Transform Isoclast®	3	3	2	1
Tebufenozide (16A)	Mimic® 700 WP	1	1	1	1
Thiamethoxam (4A)	Actara®	4	4	4	3

*When applied through micro-irrigation, has minimal direct toxicity to natural enemies, but can still affect populations, leading to later pest outbreaks.

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Table 4. Miticide and fungicide toxicity ratings to natural enemies in the orchard, where 0 = none, 1 = very low, 2 = low, 3 = medium, 4 = high, and 5 = very high.

Active and (group)	Product example	Parasitic wasps 	Lacewings 	Lady beetles 	Predatory mites 
Miticides					
Abamectin (6)	Vertimec® Pro	4	4	3	4
Clofentezine (10A)	Apollo® SC	1	1	1	1
Etoxazole (10B)	ParaMite®	1	1	–	3
Fenbutatin Oxide (12A)	Vendex®	1	1	2	2
Sulfur (M2)	Thiovit® Jet Microgranule	3	1	2	3
Fungicides					
Azoxystrobin (11A)	Amistar® 250 SC	1	1	1	1
Copper (M1)	various	2	2	2	2
Mancozeb (M3)	Dithane Rainshield Neo Tec®	2	2	2	3
Phosphorous acid (33)	Agri-fos®	–	–	–	–
Propineb (M3)	Antracol® 700 WG	3	1	4	1
Zineb (M3)	Barmac Zineb	1	–	1	–

Disclaimer: only the first product registrant of an active ingredient is listed as a trade name example, unless the original patent holder no longer manufactures the product, then the next oldest registrant product is listed as the product example. There is variation among individual species within a group on susceptibility to insecticides. For this publication, the toxicity effects are of a general nature for each active ingredient listed.

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Acknowledgements

The Citrus Industry IPDM extension program gratefully acknowledge Rob Weppler, Craig Swanbury and Mal Wallace for reviewing this fact sheet.

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Published June 2024.

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