A LIGHTER TOUCH

A LIGHTER TOUCH

Agroecological approaches to insect pest control in perennial crop systems

Establishing floral resources for improved biological control

PART 2: INSECT MONITORING OF PERENNIAL CROPS

The aim of this project is to develop an understanding of how overall biodiversity and specific natural predators can be enhanced within orchard and vineyard environments (using citrus as the model crop production system) to better manage insect pests by enhancing the abundance of beneficial insect predators and to reduce the need for applications of agrichemicals. The case study location for this project is on two citrus orchards in Gisborne.

Contents

1

Introduction

The aim of this project is to develop an understanding of how overall biodiversity and specific natural predators can be enhanced within orchard and vineyard environments (using citrus as the model crop production system) to better manage insect pests by enhancing the abundance of beneficial insect predators and to reduce the need for applications of agrichemicals. The case study location for this project is on two citrus orchards in Gisborne.

The approach taken to enhance the abundance and diversity of naturally occurring beneficial insects as biological control agents (BCAs) will be through the establishment of alternative food sources (**S**helter, **N**ectar, **A**lternative non-target insect prey, and **P**ollen = **SNAP**) and refugia through inter-row planting using selections of service plants for biodiversity plantings within the orchard.

The project involves the establishment of beneficial plant species in the orchard via planting interrow, intra-row (under canopy), and annual flower strips. The practical approaches to establish, manage and monitor these plantings will be trialled over 2 years to ensure methodologies are 'fit-for-purpose' across all types of fruit production.

This information in this report forms part of a toolkit that records the four phases of the project: (1) establishment, (2) monitoring, (3) management, and (4) evaluation.

The aim is to record the process by which perennial and annual plant species can be successfully established in an orchard, their management alongside other orchard activities, and the measurable benefits of establishing these biodiverse plantings in an orchard.

The focus of this report is on **monitoring** and records the learnings and insights through this stage.

2

Monitoring beneficial insects in perennial crops

This project is all about ecological enhancement to increase the abundance and diversity of naturally occurring beneficial insects in perennial crop orchards and vineyards.

To achieve this, plant species commonly used for this purpose are a mixture of primarily perennial legumes and non-grasses to be grown under the trees where the current herbicide strip is and a diverse grass-based pasture with a range of legumes and forbs in the inter-row. The aim is to achieve a varied ground cover within the orchard that will provide suitable **s**helter, **n**ectar, **a**lternative prey and **p**ollen (SNAP) to the beneficial insects that will help to control crop pests.

The selection of these plants and how to establish in perennial crops is detailed in the first toolkit publication. This resource is available to download from the A Lighter Touch website (https://a-lighter-touch.co.nz/establishing-floral-resources-for-improved-biological-control/).

Following establishment of biodiverse plantings in the orchard the next phase is monitoring the orchard and beneficial plantings for the presence of pests and beneficial insects that will help to control insect pests in the orchard. Regular monitoring is important for gaining a general understanding of the seasonal nature of the orchard ecosystem and the balance of beneficial insects versus insect pests.

Why should I monitor my orchard for beneficial insects?

In the same way growers monitor for pests, then beneficial insects (natural enemies) can be monitored using similar techniques.

Monitoring is the cornerstone for integrated pest management. Monitoring consists of either trapping or visual scouting on the tree or crop for pests and beneficial insects.

> "The most important aspect of good pest management remains the grower's footprints in the orchard. Such footprints, plus the accumulation of reliable inspection data and experience, will facilitate growth in the development of economical, commercially acceptable and sustainably integrated pest management strategies."
>
> M. B Georgala
> South African Fruit Journal,
> June/July 2019

Purpose of monitoring

- Monitoring helps with immediate decision making where there is a threshold associated with a particular pest or pest/natural enemy combination
- Monitoring helps to track trends during the season
- Monitoring over several seasons enables comparison of data and trends from one season to the next of pest and beneficial natural enemy levels in the orchard.

2.1 Crop monitoring

Different patterns of monitoring can be adopted depending on the size and layout of an orchard block. Typically scouting uses a 'W', 'X', or 'Z' pattern to ensure that a representative area of the block is walked through.

The most important aspect of monitoring is to ensure that the process of scouting is as random as possible. The objective is to obtain an estimate of the abundance of beneficial or pest insect species based on a representative sampling of the orchard.

Principles of good scouting:

- Start in a different place each time
- Try to cover the entire block, not just one corner
- Avoid border rows

Timing

Monitoring for beneficial insects and pests should be carried out fortnightly at a minimum through spring and summer then monitoring intervals can be extend over winter to 3-4 weeks depending on the weather and temperatures.

2.2 Monitoring steps

1. Choose a pattern to walk the block, this may be a 'W', 'X', or 'Z' type scouting pattern.

2. Randomly select 10 trees in the block along the transect of the scouting pattern (Figure 1).

3. At each scouting location (e.g. tree or vine), look at 5 different inspection sites on the inside and outside of the canopy. Therefore, for an orchard block a total of 50 sites will be examined.

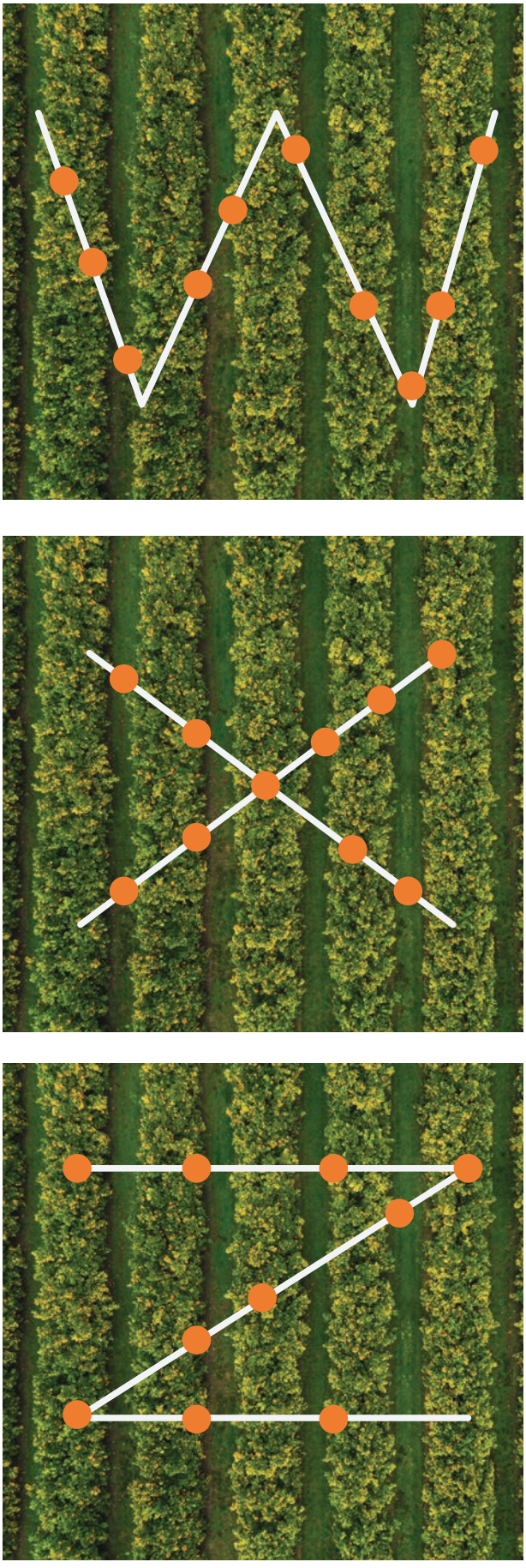
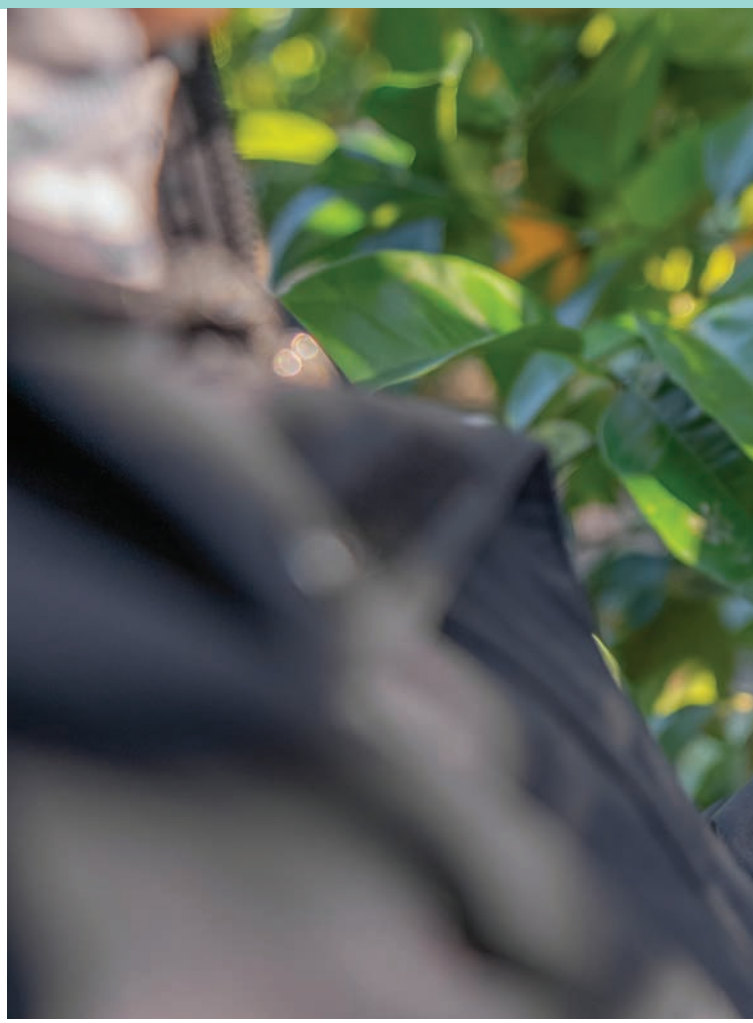


Figure 1. Scouting patterns through an orchard block. Orange dots are individual trees in the orchard selected for monitoring.



4. At each inspection point on the tree examine the leaves (upper and underside), flowers, and fruit. Note the presence of beneficial and pest insects, for example ladybirds or mites might be visible.

   To see smaller insects, it is recommended to use a hand lens or magnifying visor to closely examine the fruit, leaves and flowers.

Useful tools for scouting

- Hand lens or magnifying visor
- Field record sheets on a clipboard and pen
- Mobile phone to take photos for later identification
- A USB microscope that plugs into a smartphone or tablet for even greater magnification.

5. At each location, also look at the interrow and understory plantings for presence of beneficial insects and pests.

6. Score the presence of each beneficial insect and pest at each location. Use a scoresheet to keep a count.

7. Once 10 trees in the block have been inspected total the presence counts for each insect seen.

8. Calculate the percentage of sites where insects were present.

   For example, in the two sheets for a Washington Navel block, ladybirds were found in 1 of the 5 sites at location 1, and 2 of the 5 sites at location 4, then on the second sheet ladybirds were found 1x at location 1 and 2x at location 5. Across 10 locations (50 sites) examined, ladybirds were seen a total of 6 times.

   Therefore, there is a 12% presence of ladybirds in the orchard block.

GROWER: _____ Variety: Washington Navels Block: Trial Date: 6/4/22

	CRM	KCT	MB	GH	SCALE: SOFTWAX	SCALE: CHINESE WAX	SCALE: BLACK	SCALE: SOFT BROWN	SCALE: AS	MINOR PESTS: BCA	MINOR PESTS: FRW	MINOR PESTS: KD	MINOR PESTS: CFM	MINOR PESTS: PVH	MINOR PESTS: WF	BENEFICIALS	COMMENTS
1									M	III					L	L/B1	
2										III						W/G II	=2
3										I							
4																L/B1	=2
5										II	=10						
6																	
7																Serangium Adult	
8																=II	=2
9																	
10																	

GROWER: _____ Variety: Washington Navel Block: Trial Date: 6-4-22

	CRM	KCT	MB	GH	SCALE: SOFTWAX	SCALE: CHINESE WAX	SCALE: BLACK	SCALE: SOFT BROWN	SCALE: AS	MINOR PESTS: BCA	MINOR PESTS: FRW	MINOR PESTS: KD	MINOR PESTS: CFM	MINOR PESTS: PVH	MINOR PESTS: WF	BENEFICIALS	COMMENTS
1										1					F 2	1 LB	
2																	
3										#2						W/G	
4																	
5										#2						#2 LB	
6																	
7					Serangium = 1												
8																	
9																	
10																	

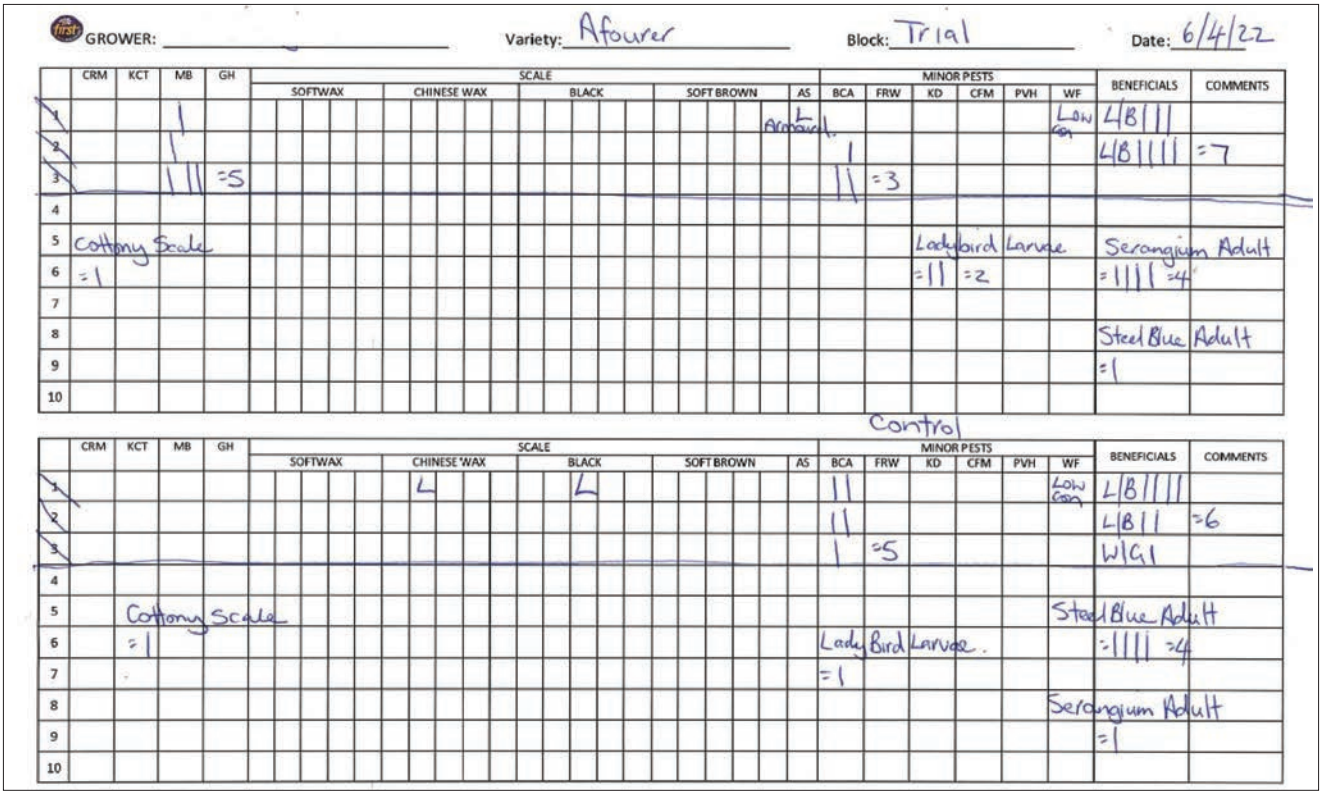
Scouting sheet

Where to monitor

- Upper side and underside of leaves
- Flowers
- Fruit
- Crop and understory / interrow plantings

Using this simple monitoring approach at regular intervals over multiple seasons a picture can be built up of the presence/absence and abundance of pests and beneficial insects in the orchard.

Generally, the greater beneficial numbers, the more resilient, healthy, and biodiverse the orchard system.

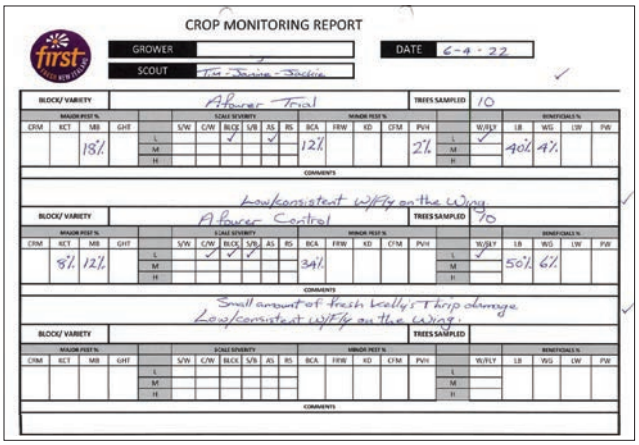

GROWER: _____ Variety: Afourer Block: Trial Date: 6/4/22

	CRM	KCT	MB	GH	SCALE: SOFTWAX	CHINESE WAX	BLACK	SOFT BROWN	AS	MINOR PESTS: BCA	FRW	KD	CFM	PVH	WF	BENEFICIALS	COMMENTS
1			1						L Armoured.						Low Con	LBIII	
2			1							1						LBIIII	=7
3			III	=5						II	=3						
4																	
5	Cottony Scale											Ladybird	Larvae			Serangium Adult	
6	=1											=II	=2			=IIII	=4
7																	
8																Steel Blue	Adult
9																=1	
10																	

Control

	CRM	KCT	MB	GH	SCALE: SOFTWAX	CHINESE WAX	BLACK	SOFT BROWN	AS	MINOR PESTS: BCA	FRW	KD	CFM	PVH	WF	BENEFICIALS	COMMENTS
1						L	L			II					Low Con	LBIIII	
2										II						LBII	=6
3										I	=5					WIGI	
4																	
5		Cottony Scale														Steel Blue	Adult
6		=1														=IIII	=4
7										Lady Bird	Larvae.						
8										=1						Serangium	Adult
9																=1	
10																	

Scouting sheet


CROP MONITORING REPORT

GROWER

SCOUT Tim - Jessica - Jackie

DATE 6-4-22

BLOCK/ VARIETY: Afourer Trial — TREES SAMPLED: 10

Major Pests: CRM 18% | Minor Pests: BCA 12% | Beneficials: LB 90% WG 47%

COMMENTS: Low/consistent WFly on the Wing

BLOCK/ VARIETY: Afourer Control — TREES SAMPLED: 10

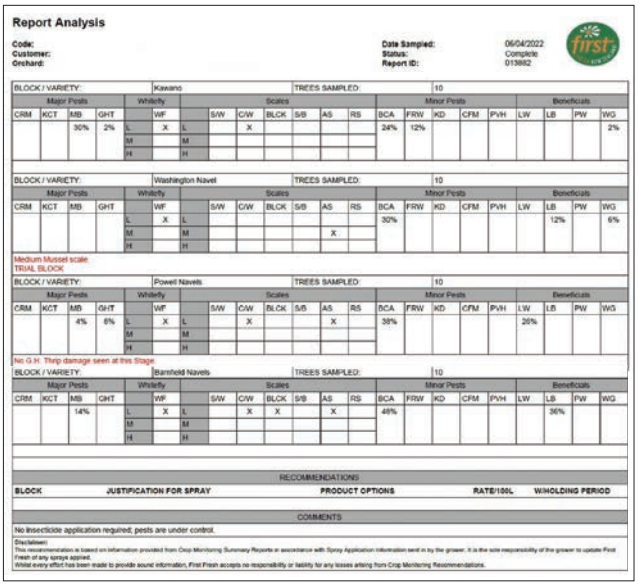
Major Pests: CRM 8% KCT 12% | Minor Pests: BCA 34% | Beneficials: LB 50% WG 6%

COMMENTS: Small amount of fresh scelly; Thrip damage. Low/consistent WFly on the wing.

BLOCK/ VARIETY: — TREES SAMPLED:

COMMENTS:

Crop monitoring report


Report Analysis

Code:
Customer:
Orchard:

Date Sampled: 06/04/2022
Status: Complete
Report ID: 013882

BLOCK / VARIETY: Kawano — TREES SAMPLED: 10

Major Pests: CRM 30% KCT 2% | Whitefly: L | Scales: C/W X | Minor Pests: BCA 24% FRW 12% | Beneficials: PW 2%

BLOCK / VARIETY: Washington Navel — TREES SAMPLED: 10

Major Pests: CRM | Whitefly: L | Scales: AS X | Minor Pests: BCA 30% | Beneficials: LB 12% WG 6%

Medium Mussel scale
TRIAL BLOCK

BLOCK / VARIETY: Powell Navels — TREES SAMPLED: 10

Major Pests: CRM 4% MB 6% | Whitefly: L X | Scales: C/W X AS X | Minor Pests: BCA 38% | Beneficials: LB 26%

No G.H. Thrip damage seen at this Stage

BLOCK / VARIETY: Barnfield Navels — TREES SAMPLED: 10

Major Pests: CRM 14% | Whitefly: L X | Scales: C/W X BLOCK X AS X | Minor Pests: BCA 48% | Beneficials: LB 36%

RECOMMENDATIONS

BLOCK	JUSTIFICATION FOR SPRAY	PRODUCT OPTIONS	RATE/100L	WITHOLDING PERIOD

COMMENTS

No insecticide application required; pests are under control.

Disclaimer:
This recommendation is based on information provided from Crop Monitoring Summary Reports in accordance with Spray Application information sent in by the grower. It is the sole responsibility of the grower to update First Fresh of any sprays applied.
Whilst every effort has been made to provide sound information, First Fresh accepts no responsibility or liability for any losses arising from Crop Monitoring Recommendations.

Report Analysis

2.3 Record keeping

As you scout the orchard, record what you see.

Many scouting sheets have fields to record common insect pests and beneficials.

The examples shown are records of scouting by First Fresh crop scouts in the Gisborne citrus floral resourcing trial blocks.

An example of a field scouting record sheet that can be copied and used is included in Section 5 - References and Resources.

Once the in-field scouting is completed the results can be compiled into a summary report. Entering the counts into an Excel spreadsheet can also be helpful to track changes in insect abundance.

The report examples shown are the result of scouting in the Gisborne citrus trial blocks by First Fresh crop scouts.

2.4 Alternative monitoring approaches

Walking through the orchard and scouting trees is an effective way to gauge the level of pest and beneficial insects and the diversity present.

Other approaches such as sticky traps, sweep nets, suction sampling are also used for crop monitoring. Generally, these approaches are less time consuming on orchard. For example, a trap can be set and left for a period of time before it is collected and examined. The downside with these approaches, such as a sticky trap that does not use a lure or an attractant, is that the assessment of the trap can be time consuming as hundreds of insects can be attracted to the trap. It also requires specialist equipment such as a dissecting microscope to clearly view insects caught on the trap.

Depending on what the monitoring is trying to achieve trapping may provide information about less common pests and beneficials which may not be part of a standard scouting protocol.

Yellow sticky trap (Credit: Plant & Food Research)

2.4.1 Common types of monitoring approaches

Yellow sticky traps

As the name suggests sticky traps have a non-drying adhesive surface to trap small flying insects such as aphids, leaf miners, fungus gnats, thrips, white flies, black flies and midges. The yellow colour acts as an attractant. Generally, these traps are hung in the orchard and can be left for 24 hours - up to two weeks. Traps left for 24 hours to a week will provide a snapshot of orchard pests and beneficials and can be useful for early pest detection and monitoring. The grid on the trap enables easier counting.

Yellow sticky trap monitoring – the stick trap is covered with plastic wrap to preserve the insects caught on the trap and for easier handling of the trap. A waterproof marker has been used to circle insects of interest. (Credit: Plant & Food Research).

Pitfall trap

Window trap (Credit: Plant & Food Research)

Sweep net

Window (pane) trap

This trap uses clear glass or Perspex that flying insects are unable to see. Insects fly into the panes, are stunned, and fall into the collecting trough where they drown in soapy water.

Sweep netting

Sweep nets are sturdy nets, often with a canvas or mesh bag, that are used to collect insects and other invertebrates from long grass or tree canopies.

Pitfall trap

This device is used to trap insects that are active on the ground surface. Pitfall traps usually consist of a container that is buried so that the lip of the beaker is level with the ground surface. Placing a second container inside the first will make it easier to remove and replace. Insects reaching the lip of the container slip and fall in. Sometimes alcohol or another substance (soapy water) is poured into the trap so that any insects falling in are killed. It is important to keep the trap covered to protect from rain and sun. Generally, traps are left for 24 – 48 hours before they are removed.

Suction sampling

A suction sampler is a powered device used to collect insects. The suction sampler is similar to a vacuum cleaner (or "leaf blower" used in reverse). Insects are sucked into the device and collected.

Pheromone trap

This is a type of insect trap that uses pheromones to lure insects. Sex pheromones and aggregating pheromones are the most common types used. A pheromone-impregnated lure, such as the red rubber septa in the picture, is encased in a conventional trap such as a Delta trap (picture). Pheromone traps are used both to count insect populations by sampling, and to trap pests such as citrus flower moths to destroy them.

Citrus flower moth trap with lure
(Credit: Plant & Food Research).

Suction sampler

Citrus flower moth trap positioned in a lemon tree
(Credit: Plant & Food Research).

3

Monitoring equipment

Monitoring in the orchard requires a few key items of equipment.

Mobile phone

Many modern phones have excellent macro capability. A quick photo can help with identifying what the insect is. The benefit of taking photos on a mobile phone is that anything unusual can be sent through to app-based naturalist platforms such as INaturalistNZ (https://inaturalist.nz/), Find-A-Pest (https://www.findapest.nz/), and Google lens (https://lens.google/) for insect identification.

Hand lens

Can be purchased at various magnifications and typically have magnification powers of 5×, 10×, 14×, and 20×. 10× is generally best for insects.

Magnifying visor

Using a visor leaves both hands free and allows magnified vision from both eyes at the same time. Magnifiers can provide 1.5x to 10x magnification.

To view insect life stages in close-up a **digital microscope** that uses a USB connection to a computer provides up to 300x magnification. Prices range up to $250, this is a very cheap option compared to purchasing a more traditional dissecting microscope.

Hand lens

Magnifying visor

Digital microscope (Image retrieved from https://www.vernier.com/product/usb-digital-microscope/)

4

Beneficial insects

Agroecological enhancement by introducing plants to the orchard that provide resources such as shelter, nectar, alternative prey/food sources and pollen (SNAP) will support a wider diversity of beneficial insect species that will in turn attack pest species.

This section focuses on common beneficial insects that will be seen in orchards and vineyards. The pests that these beneficial insects' prey upon are noted. However many pests can be crop-specific and it is recommended to consult crop-specific pest information for details on crop pests, their lifecycles and signs and symptoms of damage in orchards and vineyards.

Steelblue ladybird larvae
(Credit: iNaturalistNZ, Grey Smith)

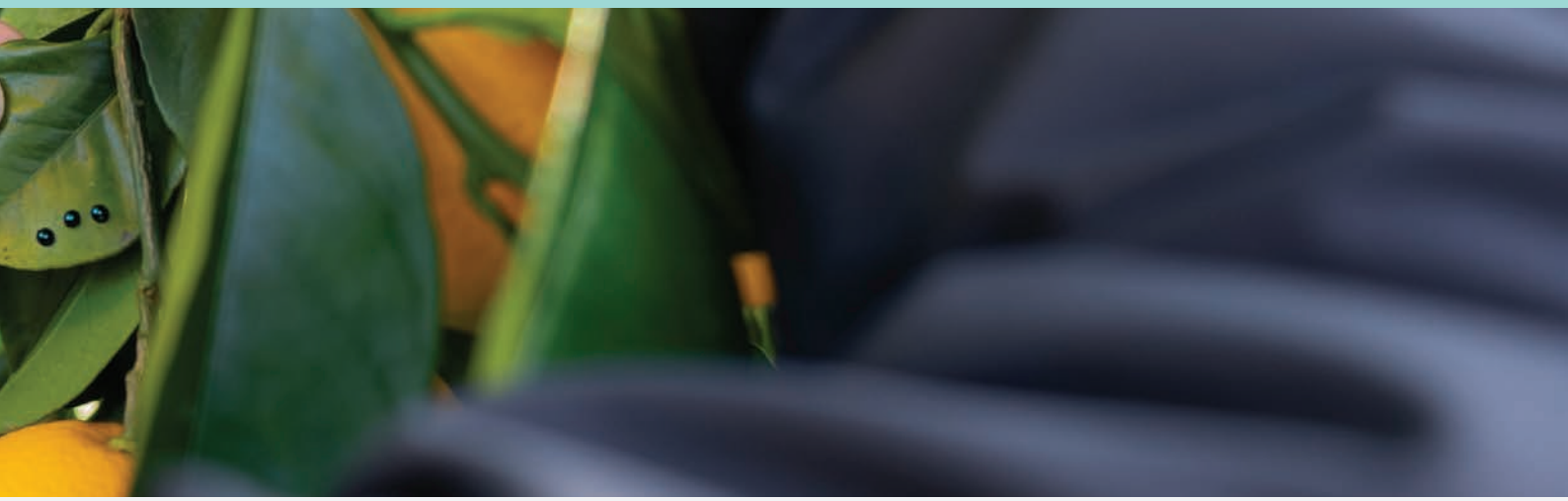
Steelblue ladybird (Credit: iNaturalistNZ, Jacqui Geux)

The types of beneficials largely fall into two broad categories: predators and parasitoids.

In New Zealand the predator insects are predominantly generalists, meaning they are not restricted to feeding on just one type of insect pest but feed across a range of insect species. Predators include ladybird - adults and larvae, lacewing larvae, hoverfly larvae, and spiders.

Parasitoids are usually small parasitic wasps or sometimes flies and lay eggs on or in the host where larvae develop. Parasitoids are generally quite host specific.

Some of the main beneficial insects that might be encountered in an orchard are described in this section.



Citrus whitefly ladybird
(Credit: iNaturalistNZ, Cameron Rodda)

Ladybugs or Ladybirds

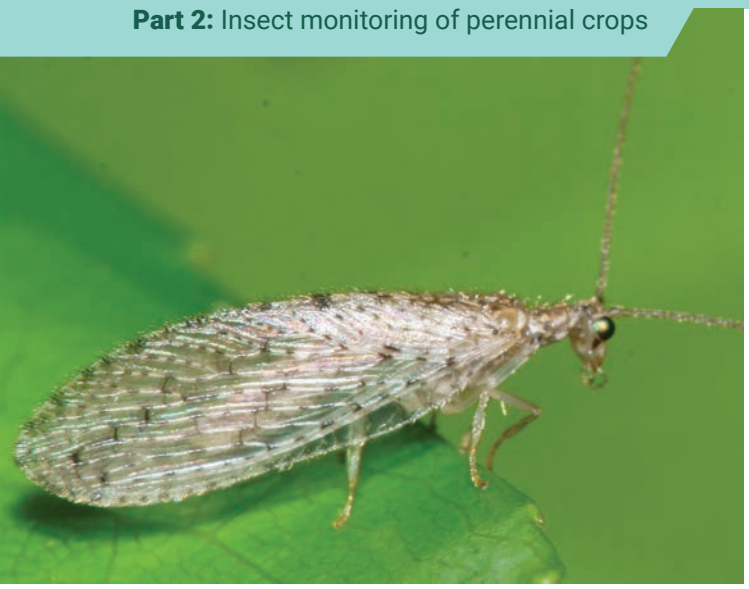
Predator of armoured scale, soft scale, aphids, leafroller eggs, mealybugs, and mites

Common species: Steelblue ladybird *(Halmus chalybeus)* and Citrus whitefly ladybird *(Serangium maculigerum)*, Eleven spotted ladybird *(Coccinella undecimpunctata)*

There are a number of ladybirds (Coleoptera: Coccinellidae) that act as generalist predators, such as the steelblue ladybird, which is a predator of armoured scale, soft scale, aphids, leafroller eggs, mealybugs, and mites.

Steel blue ladybird was imported to New Zealand from Australia over a century ago as a predator of black scale. It is now common on orchards, where both larvae and adults are important predators of soft wax scale and Chinese wax scale. Both the young larvae and adults eat pests. However, the larvae feed more than the adult does.

Adult ladybirds can fly, and can disperse considerable distances, while the larvae can move quite rapidly on the plant, but, as they can only walk, they can only move across the plant they are on and touching plants. The larvae pupate on the plant in a sheltered location. The ladybirds overwinter as adults, singly or in small clusters, in leaf folds and other nooks and crannies above ground in trees and shrubs. There are several generations a year, especially in warmer climates.



Tasmanian lacewing
(Credit: iNatuaralistNZ, Uwe Schneehagen)

Tasmanian lacewing larvae (Credit: iNatuaralistNZ)

Lacewings

Predator of aphids, mites, moths, and caterpillars

Common species: Tasmanian lacewing *(Micromus tasmaniae)* and Green lacewing *(Cryptoscenea australiensis)*, Australian variable lacewing *(Drepanacra binocula)*

Both the adult lacewing and its larvae prey on aphids, mealybugs, mites, moths, and caterpillars. Australian variable lacewing (*Drepanacra binocula*) and the Tasmanian lacewing (*Micromus tasmaniae*) are two of the more common lacewing species in New Zealand. These are Australian species that have been in New Zealand since the late 19th and early 20th century.

Large hoverfly (Credit: iNaturalistNZ, Steve Kerr)

Hoverflies

Predator of aphids, mealybugs and other insects with soft bodies

Common species: Small hoverfly *(Melanostoma fasciatum)*, Large hoverfly *(Melangyna novaezelandiae)*

A hoverfly (or flower fly) (Syrphid flies) can look like a wasp. As the name suggests hoverflies hover around flowers and feed on nectar and pollen. Hoverfly larvae eat aphids, mealybugs and other insects with soft bodies. Adults feed on nectar and pollen.

The small hoverfly (*Melanostoma fasciatum*) is endemic and present throughout New Zealand, where it occurs in grassland, vegetable crops, field crops, cereals, gardens and other habitats with low growing vegetation. *Melangyna novaezelandiae* (commonly referred to as the "large hoverfly") is another hoverfly endemic to New Zealand and widespread in agricultural environments.

Australian leaf-roller fly on NZ Jasmine
(Credit: iNaturalist, Katja Schulz)

Predatory flies - Tachinid flies

Parasites (larvae – maggots) of caterpillars, bugs, moths, grasshoppers, and earwigs

Common species: Australian leafroller fly *(Trigonospila brevifacies)*

Tachinid flies resemble house flies and are commonly known as parasites of caterpillars, bugs, moths, grasshoppers, and earwigs. They lay their eggs near or in the host; the larvae then burrow their way into the body of the host, sucking its bodily fluids and eventually killing the host. The adult Tachinid flies feed on nectar and pollen.

Daddy long legs spider (Credit: iNaturalist, Kyle Elshoff)

Spiders

Predator of a variety of insects.

Common species: Daddy long legs *(Pholcus phalangioides)*

Spiders feed on a variety of insects, and their prey differs according to the type (family) of spider.

Agistemus longisetus eating citrus red mite egg. (Credit: Lisa Jamieson, Plant & Food Research)

Anystis baccarum (whirligig mite) A very common general predator which feeds on a range of insect eggs and young larvae (2mm size). (Credit: Plant & Food Research)

Predatory mites

Predator of leafroller, thrips and other insects

Common species: Whirligig mite *(Anystis baccarum*), Orange predatory mite *(Agistemus longisetus)*

Phytoseiid mites are an important group of predatory mites. These include *Anystis baccarum*, which is a bright red or orange predatory mite (whirligig mite) that feeds on eggs and young leafroller larvae as well as thrips and other insects. It is characterised by a distinctive 'whirlygig' type of movement. Another red or orange predatory mite is *Agistemus longisetus*, which is often found eating citrus red mite eggs. Many phytoseiid species also feed on pollen and this allows populations to build up and be maintained in the absence of high densities of their prey.

Pirate bug (Credit: iNaturalist, Paul Bowyer)

Minute Pirate Bugs

Predator of smaller insects, aphids, spider mites, thrips, whitefly

Common species: Pirate bug *(Orius vicinus)*

The genus Orius (commonly called minute pirate bug) consists of omnivorous bugs in the family Anthocoridae (pirate bugs). Adults are 2–5 mm long and feed mostly on smaller insects, larva and eggs, such as aphids, spider mites, thrips, jumping plant lice, and whitefly, but will also feed on pollen and vascular sap. These predators are common in gardens and landscapes. Some species are raised commercially and sold to growers as a form of biological control.

Ground beetle (Credit: iNaturalist, Shona Sangster)

Ground dwelling beetles – Carabids

Generalist predator

Common species: beetles in the Genus Mecodema.

The Carabidae (Insecta: Coleoptera) is one of the largest insect families in New Zealand with an estimated 600 species, 90% of which are endemic. Mecodema is a genus of large flightless ground beetle (Carabidae) endemic to New Zealand.

Adult beetles hunt primarily on the soil surface but will occasionally climb into the foliage in search of food. In addition to the adults being beneficial predators, the burrowing larvae of these beetles seek out and feed on pests in the soil. Many ground beetle species have broad feeding habits, eating not only other insects but also seeds of plants (including weeds).

European earwig (Credit: iNaturalist, Katja Schulz)

European Earwig

Predator of aphids and other insects

Common species: European earwig or common earwig *(Forficula auricularia)*.

The European or common earwig (*Forficula auricularia*) was introduced to New Zealand by accident in the 1800s. It is widely distributed in New Zealand, and is omnivorous, feeding on both plant material and arthropods. It can feed on eggs and active stages of a wide range of species of Lepidoptera, Coleoptera, Diptera, Homoptera, Hymenoptera and Collembola. *F. auricularia* has been described as particularly voracious predators of aphids, and more efficient than lacewings or ladybirds.

Aphidus colemani (Credit: iNaturalist)

Parasitic wasps

Parasitoid of caterpillars, aphids, whitefly, scale insects, thrips and mealybugs

Common species: *Thripobius semiluteus, Aphelinus mali, Aphidius colemani,* and *Encarsia formosa*.

Parasitic wasps are a variety of tiny wasps that do not sting. Parasitic wasps help control pests by laying their eggs in or on the bodies of insect pests like caterpillars, aphids, whitefly, and mealybugs. The parasitoid egg hatches and then a larva emerges to feed inside or on the host. This feeding of the parasitoid larva kills the host and the parasitoid then pupates in or near the dead or dying host. The adult emerges from the pupal case to fly around and search for a new host, and the life cycle continues. Two species are commonly used for biological control of greenhouse whitefly in NZ: *Aphidius colemani*, and *Encarsia formosa*.

5

References and resources

Merfield, C. N. & Shields, M. W. (2021). Agroecological pest management in citrus. Lincoln: Merfield Agronomy Ltd. (Available online: https://merfield.com/research/2021/agroecological-pest-management-in-citrus-2021-merfield-shields.pdf, accessed June 2022).

iNaturalistNZ (https://inaturalist.nz/) an online resource (app or pc based) for species identification. iNaturalist is an open-source global nature observation system.

Find A Pest (https://www.findapest.nz/) is a downloadable app that provides users with simple options to report potential insect and fungal pests of plants, pest weeds, and a range of other animal pests.

Citrus Academy (2017). Integrated Pest Management for Citrus, 2 Citrus pest Monitoring, Learner Guide, Citrus Academy. 29p. (Available online: http://www.citrusresourcewarehouse.org.za/home/document-home/learning-aids-and-resources/ca-citrus-av-series-learning-material/ipm-for-citrus/5841-integrated-pest-management-learner-guide-2/file, accessed June 2022.)

UC IPM (2012) Integrated pest management for citrus. General predators in citrus. Third edition. Publication 3303. University of California Agriculture and Natural Resources. (Available online: http://ipm.ucanr.edu/IPMPROJECT/ADS/General_predators_in_citrus.pdf, accessed June 2022).

Field scouting sheet for beneficial insects

Tree/vine	LB	PM	LW	SP	EA
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					

LB = ladybird, PM = predatory mites, LW = Lacewing, SP = spiders, EA = earwigs, PF = predatory flies (hoverflies), PW = parasitic wasps, PB = Pirate bugs, B = Ground beetles

Grower: | **Block ID:**

Variety: | **Date:**

PF	PW	PB	B	Totals	Other comments

Notes

A LIGHTER TOUCH

a-lighter-touch.co.nz