Invertebrates and Fungi Associated with Japanese Honeysuckle, *Lonicera japonica* (Caprifoliaceae), in New Zealand

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Project and Client

A survey of the invertebrate fauna and fungi associated with Japanese honeysuckle, *Lonicera japonica*, in New Zealand was carried out between November 2004 and April 2005 by Landcare Research for regional councils and the Department of Conservation.

Objective

- To survey the invertebrate fauna and fungi associated with Japanese honeysuckle, *Lonicera japonica*, in New Zealand, and identify the herbivores (and their associated predators and parasitoids) and fungal pathogens present.

Method

- The invertebrate fauna and fungi associated with Japanese honeysuckle were sampled at 33 New Zealand sites, ranging from Horeke in the Hokianga Harbour in the north of the North Island to Ross on the West Coast of the South Island in the south.

Results

- No specialist Japanese honeysuckle invertebrates were found during the survey.
- The overall damage that could be attributed to invertebrate herbivory was minimal.
- The most obvious foliage damage appeared to be caused by the larvae of a range of moth species (especially leafrollers) and molluscs (slugs and snails).
- Two sap-feeders, *Scolypopa australis* (the passionvine hopper) and *Siphanta acuta*, were the only invertebrate species found during the survey to be classed as 'abundant'.
- Thrips occasionally produce silvery-coloured patches on Japanese honeysuckle foliage but they probably have little overall effect.
- Generalist predators found on Japanese honeysuckle include spiders, ladybirds, lacewings, earwigs, ants and praying mantids.
- A total of 461 fungal isolates was obtained from 469 Japanese honeysuckle tissues plated.
- A high frequency of fungal colonisation of Japanese honeysuckle was observed with 98.3% of tissue fragments colonised.
- At least 35 fungal species were isolated into culture and identified from diseased Japanese honeysuckle tissues.
- No significant primary leaf, stem or flower pathogens were isolated from Japanese honeysuckle.
- Three primary pathogens were identified directly from diseased specimens.
- *Pseudocercospora lonicera*, a leaf spot pathogen, was present on Japanese honeysuckle at 29 locations throughout New Zealand.
- *Chondrostereum pupureum*, a fungus developed and registered as a mycoherbicide for tree weeds overseas, was collected from the woody base of a vine in Northland.
- Honeysuckle leaf blight, caused by a fungus *Insolibasidium deformans*, was identified on leaves from Auckland.

Conclusions

- Japanese honeysuckle is attacked by a wide range of native and introduced invertebrates in New Zealand but overall damage appears to be minimal and none of the herbivore niches on Japanese honeysuckle are well utilised in New Zealand.
- Foliage feeders (most noticeably lepidopterous larvae, molluscs and thrips) appear to be the most damaging invertebrates currently feeding on Japanese honeysuckle in New Zealand.
- A range of weak and secondary opportunistic leaf pathogens was found to be associated with minor superficial leaf spots on Japanese honeysuckle populations in New Zealand.
- There is little potential to use any of these fungi as either inundative or classical agents against the rapidly expanding Japanese honeysuckle infestations.

Recommendation

- Given that invertebrate herbivore damage to Japanese honeysuckle in New Zealand is minimal and that no specialised pathogenic fungi are known to be present on the weed in New Zealand, we recommend that a classical biological control programme for Japanese honeysuckle should proceed.

1. Introduction

A survey of the invertebrate fauna and fungi associated with Japanese honeysuckle, *Lonicera japonica*, in New Zealand was carried out between November 2004 and April 2005 by Landcare Research for regional councils and the Department of Conservation. This was a recommendation of a feasibility study investigating the prospects of biological control of Japanese honeysuckle in New Zealand (Standish 2002).

2. Background

Japanese honeysuckle, *Lonicera japonica* Thunb. (Caprifoliaceae), is a weed of native forest remnants and shrublands throughout most of the North Island and northern South Island of New Zealand (Standish 2002). It is a perennial climbing and twining woody vine of the honeysuckle family (Caprifoliaceae) and spreads by seeds, underground rhizomes, and above-ground runners. It grows rapidly and can create dense tangled thickets that can smother and engulf small trees and shrubs. In New Zealand Japanese honeysuckle blooms from September to May with sweetly fragrant white flowers, tinged with pink and purple, fading to yellow with age. The fruit, a many-seeded black pulpy berry, matures in autumn.

According to information accessed by the feasibility study conducted by Dr Rachel Standish (Standish 2002), Japanese honeysuckle is native to temperate eastern Asia. It has naturalised in Australia, North America, Hawaii, southwest Britain, southern Chile and Argentina (Williams et al. 2001), southern Brazil (R. Barreto, Universidade Federal de Vicosa, Brazil, pers. comm.), and parts of Europe (Bay of Plenty Regional Council 1998). It was first recorded as being naturalised in New Zealand in 1926 (Webb et al. 1988) but is known to have been cultivated here since 1872.

Japanese honeysuckle affects hedges, roadsides, wastelands, open scrub, shrublands, woodlands, forest margins (including pine plantations), wetlands and riparian zones (Williams et al. 2001). It has spread via deliberate plantings (Auckland Regional Council 1998), stem fragments dumped in garden refuse (Department of Conservation 2001), hedge-cutting machinery, and grazing mammals (Williams et al. 2001). Seeds are dispersed by birds, although seedlings are rare (Williams et al. 2001).

Once introduced to a site, Japanese honeysuckle quickly builds up a mass of vegetative material using host plants and its own stems for support (Williams & Timmins 1999). It is a hardy plant, tolerant of cold winter temperatures (it has been noted as growing until the first frosts) and a wide range of soil substrates including poorly draining soils and those high in salt and heavy metals (Williams et al. 2001). It spans all 13 Department of Conservation conservancies and is regarded as a threat to conservation in all but Canterbury, Otago and Southland conservancies (Standish 2002).

Japanese honeysuckle is generally regarded as a difficult weed to control (Williams et al. 2001; Department of Conservation 2001), and biological control could offer some advantages

over current control methods. Use of host-specific biological control agents would reduce chemical herbicides impacts on desirable flora. Biological control also offers continuous action and self-dispersal that current control methods do not offer. There have been no previous biological control programmes for Japanese honeysuckle elsewhere in the world but other countries may be interested in collaborating with New Zealand on such a programme. Several potential biocontrol agents, including insects and pathogens, are known from the native range of Japanese honeysuckle (Standish 2002), and a thorough survey in the native range would no doubt find many more potential biocontrol agents.

This report describes the results of a survey of the invertebrate fauna and fungi associated with Japanese honeysuckle in New Zealand. The main aims of the survey were to determine whether any specialist Japanese honeysuckle invertebrates or fungi are already present in New Zealand, whether any generalist invertebrate herbivores or fungal pathogens are exerting a significant adverse impact on Japanese honeysuckle in New Zealand, and to record the invertebrate parasitoids and predators associated with the herbivorous invertebrates on Japanese honeysuckle.

3. Objective

- To survey the invertebrate fauna and fungi associated with Japanese honeysuckle, *Lonicera japonica*, in New Zealand and identify the herbivores (and their associated predators and parasitoids) and fungal pathogens present.

4. Methods

4.1 Invertebrates

Invertebrate fauna of Japanese honeysuckle, *Lonicera japonica*, were surveyed at 33 New Zealand sites between November 2004 and April 2005 (Fig. 1). At each site, 10 collection locations were selected randomly. A collecting tray, 80 cm x 80 cm, was placed under suitable parts of selected plants, and the foliage above the tray was hit five times with a solid stick. Most invertebrates that fell onto the tray were collected with an aspirator and preserved in 95% alcohol. Caterpillars (Lepidoptera) and immature stages of other groups (e.g., Heteroptera) were collected live and placed, along with Japanese honeysuckle foliage, in ventilated containers to rear through to adult for identification. Parasitoids emerging from the larvae were identified.

A rapid visual inspection (generally less than 1 minute for each of the 10 collection locations at each site), was made of foliage, growing points, and stems, for signs of invertebrates such as gall-formers, leaf miners, stem borers, and scale insects. Sections of the stems were cut to look for signs of invertebrates or their damage. Invertebrates found during the visual inspections were collected live, along with the plant material they were on, for identification. If fruit was present, approximately 100 berries were collected randomly from each site and stored in ventilated rearing containers to identify fruit-feeders and seed-feeders. At each site,

a visual estimate was made of the amount of herbivore-related damage, and the likely cause of the damage was noted (e.g., adult beetles, leafroller caterpillars).

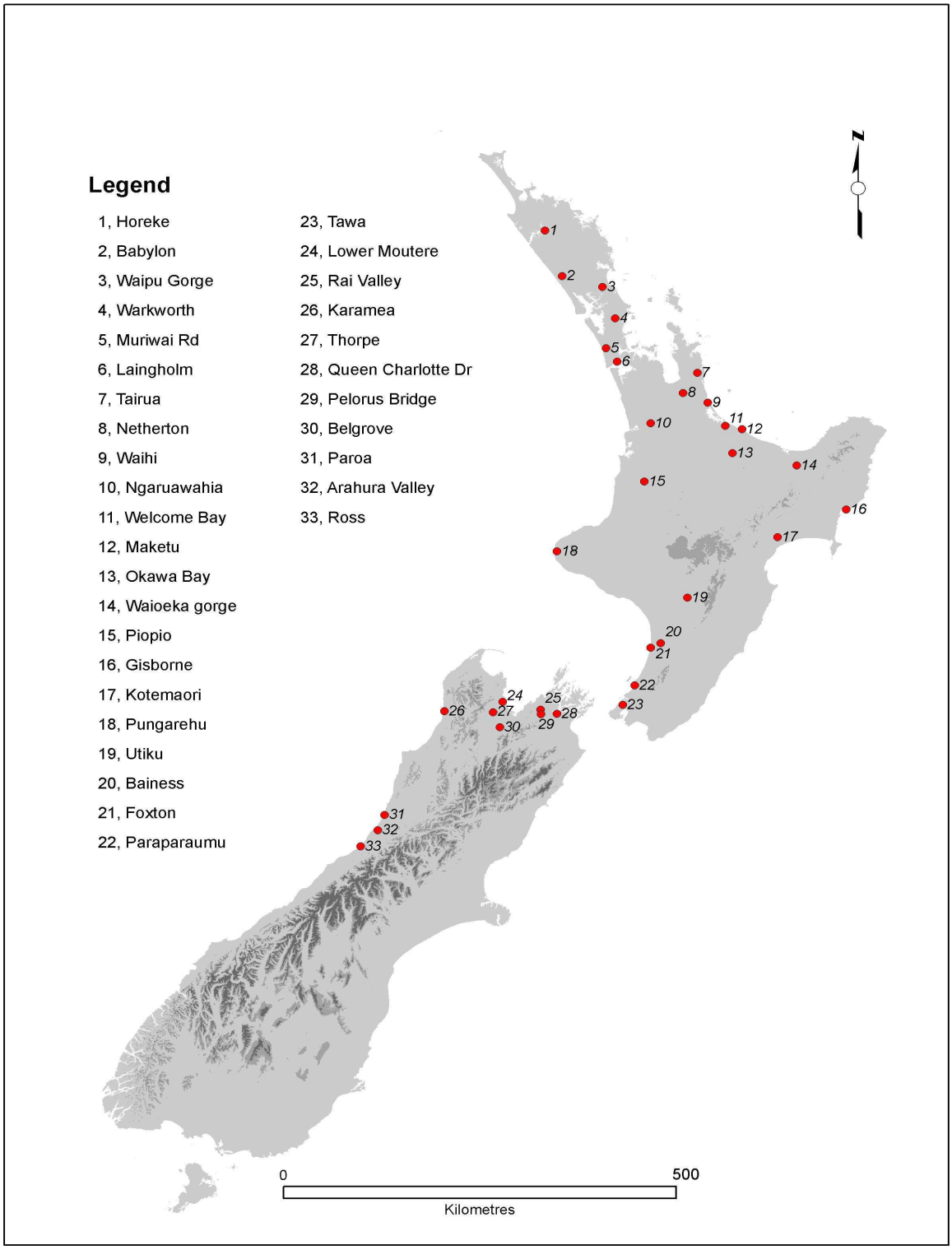

Fig. 1 Japanese honeysuckle (*Lonicera japonica*) sites sampled for fungi and invertebrates (2004–05)

The invertebrates collected were identified to species or genus level where feasible. However, some invertebrates were placed into groups of related species (e.g., 'spiders'). They were then ranked on a scale of abundance according to the total number of individuals collected, and the number of sites at which they were present. They were classed as rare, occasional, common or abundant according to the definitions below:

rare: fewer than 5 individuals collected
occasional: 5–24 individuals collected, **or** present at fewer than five sites
common: 25+ individuals collected **and** present at five or more sites
abundant: 200+ individuals collected **and** present at 10 or more sites

4.2 Fungi

Fungi associated with Japanese honeysuckle were surveyed at the same 33 sites (Fig. 1) from which invertebrates were collected. At each site, plants at each of the 10 invertebrate collection points were also inspected closely for signs of pathogen damage. Other Japanese honeysuckle plants in the area were examined more superficially for obvious disease symptoms and any fungi collected were allocated a unique specimen number. Diseased leaves, leaf petioles, stems, flowers, flower petioles, or pods were placed in paper bags and kept cool in transit before processing. Collected material was examined within 5 days of collection.

In the laboratory, disease symptoms were recorded and photographed. A dissecting microscope was used to search necrotic areas for fungal reproductive structures. Small pieces of tissue (c. 3 × 3 mm) were cut from the edge of diseased areas and surface sterilised. Sterilisation was by immersion in 2% hypochlorite for 1 minute, followed by rinsing in two beakers of sterile water. The tissue fragments were blotted dry with sterile filter paper and placed on potato dextrose agar (Difco Labs, Detroit, MI, USA) with 0.02% streptomycin (Sigma, St Louis, MI, USA), contained in 9-cm Petri dishes. Plates were incubated under near-ultraviolet and white light (12 h photoperiod) at temperatures of 22 ± 2°C (day) and 18 ± 2°C (night).

Fungal colonies that grew out of the tissue fragments and produced spores were identified to the species level where possible. Taxonomic literature and fungal systematists were consulted to determine which of the identified fungi were likely to be causing the damage with which they were associated. Each identified isolate was given a unique number.

Basidiocarps (or fruiting bodies) of *Chondrostereum purpureum* were collected from the base of a vine at a single site (Waipu Gorge, Northland). Methods to isolate this fungus in pure culture were as follows. Tissues of the basidiocarp as well as the infected vine wood where the fruiting body was attached, were dissected with a scalpel, surface sterilised (as described above, except immersion in 2% hypochlorite was for 5 minutes) and plated onto Nobles agar amended with 0.02% streptomycin antibiotic. Nobles agar is a type of Malt Extract Agar, in which 6.25 grams of Malt Extract (Difco) is mixed with 10 grams agar (Difco) into 500 mls distilled water. Plates were incubated in the dark at temperatures of 22 ± 2°C (day) and 18 ± 2°C (night).

5. Results

5.1 Invertebrates

A full list of invertebrates found in association with Japanese honeysuckle during this survey is presented in Appendix 1. None are specialists on Japanese honeysuckle.

Herbivores

A total of 108 herbivorous invertebrate species was recorded from Japanese honeysuckle during this survey. An additional 12 groups of taxonomically related herbivorous species were recorded (where identification to species level was not feasible). Two herbivorous species, *Scolypopa australis* (Walker) (the passionvine hopper) and *Siphanta acuta* (Walker), were classed as 'abundant'. A further 16 herbivorous species or taxonomic groupings were classed as 'common', 30 were classed as 'occasional', and 72 were classed as 'rare' (Appendix 1). A list of the abundant, common and occasional herbivorous invertebrates is given below (Table 1).

Foliage feeders: At many survey sites more than 25% of the Japanese honeysuckle leaves examined showed signs of invertebrate herbivory but most of this damage was minor. Leaves that were more than 20% consumed were rare, and the overall amount of foliage that appeared to have been consumed or damaged by herbivores was estimated to be less than 5%. Feeding damage was most obvious on older foliage.

The most obvious foliage damage appeared to be caused by the larvae of a range of moth species, especially tortricid larvae (leafrollers) and to a lesser extent noctuid larva. If the families Tortricidae and Noctuidae were treated as taxonomic groups they would be classed as 'abundant' and 'common' respectively, and these rankings have been included in Table 1 next to these families to emphasize their relative importance. Leafroller larvae were sometimes found still inside 'rolled' leaves on the plant, but more commonly they were collected from the beating tray after being dislodged. A number of moth larvae, collected to rear through to adult for identification, died during rearing, and parasitoids emerged from some of them (Table 3).

Foliage (especially foliage close to the ground) often showed typical slug or snail damage and slime trails were sometimes visible. If snails and slugs were treated as a combined group (Gastropoda) they were classed as 'abundant' (Table 1).

Banana silvering thrips, *Hercinothrips bicinctus* (Bagnall) and greenhouse thrips, *Heliothrips haemorrhoidalis* (Bouche), were collected from six and four sites respectively. At some sites they were very numerous, producing distinctive silvery-coloured patches on the foliage, especially during late summer/autumn.

Forty-six species, or groups of taxonomically related species, of herbivorous adult beetles were collected during the survey but foliage damage attributed to beetles was minimal.

Fruit feeders: Little or no damage that could be attributed to invertebrates was observed on the fruit. However, four species of sap-feeding shield bugs (Pentatomidae) were found during the survey and they are known to feed on fruit as well other parts of plants (Larivière 1995).

Omnivorous European earwigs, *Forficula auricularia* Linnaeus, were 'common' in the survey and are known to damage the fruit of a number of plant species (http://www.ipm.ucdavis.edu/PMG/PESTNOTES/pn74102.html). Fruit that was collected and stored produced a variety of saprophytic or fungivorous invertebrates, but they would probably not damage living fruit.

Flower feeders: Little damage that could be attributed to invertebrates was observed on the flowers. However, the New Zealand flower thrips, *Thrips obscuratus* (Crawford), were commonly found during the survey and they are known to be capable of causing considerable damage to flowers of a wide range of plant species (Mound & Walker 1982). Moth larvae and European earwigs, *Forficula auricularia*, may also consume Japanese honeysuckle flowers (http://www.rosecare.com/pests.html).

Sap-feeders: Scolypopa australis (the passionvine hopper) and *Siphanta acuta* were the only sap-feeding invertebrates found during the survey to be classed as 'abundant'. A further 35 species, or groups of taxonomically related species, of sap-feeders were found during the survey (Appendix 1). The damage caused by sap-feeders, either directly by the removal of nutrients or indirectly by puncturing the plant and possibly allowing entry of pathogens, is very difficult to quantify.

Leaf miners: No leaf-mining invertebrates were found on Japanese honeysuckle during this survey.

Stem borers: Long-horn beetle (family Cerambycidae) adults were commonly found on Japanese honeysuckle, but Japanese honeysuckle stems that were checked did not show evidence of attack by stem-boring long-horn beetle larvae, or any other stem borers. Most of the Japanese honeysuckle material sampled was growing in close association with other vegetation and it is possible the long-horn beetles found on Japanese honeysuckle were associated primarily with the other plants on which Japanese honeysuckle was growing.

Table 1. Abundant, common, and occasional herbivorous invertebrates, collected from Japanese honeysuckle at 33 New Zealand sites during 2004–2005

Taxon	Common Name	Feeding Site	Frequency	Origin
Phylum Mollusca	**molluscs**			
Class Gastropoda	slugs and snails	foliage	all gastropod species combined – abundant	
Cantareus asperses	brown garden snail	foliage	common	introduced
unidentified snails		foliage	common	
unidentified slugs		foliage	occasional	
Phylum Arthropoda				
Class Arachnida				
Acarina	**mites and ticks**			
Tydeidae				
Orthotydeus californicus		foliage	occasional	introduced

Taxon	Common Name	Feeding Site	Frequency	Origin
Class Insecta	**Insects**			
Coleoptera	**Beetles**			
Cerambycidae	**longhorn beetles**			
Hybolasius crista		adults: foliage	occasional	native
Psilocnaeia spp.		adults: foliage	occasional	native
Xylotoles griseus		adults: foliage	occasional	native
Xylotoles griseus or *Xylotoles laetus*		adults: foliage	occasional	native
Chrysomelidae	**leaf beetles**			
Eucolaspis sp.	bronze beetle	foliage	common	native
Curculionidae	**Weevils**			
Asynonychus cervinus	Fuller's rose weevil	foliage	common	introduced
Catoptes spp.		foliage	common	native
Irenimus spp.		foliage	common	native
Microcryptorhynchus sp.		foliage	occasional	native
Peristoreus spp.		foliage	occasional	native
Phlyctinus callosus	garden weevil	foliage	occasional	introduced
Elateridae	**click beetles**			
Conoderus exsul	pasture wireworm	adults: foliage/flowers larvae: plant roots and invertebrates	common	introduced
Melandryidae	**leaping beetles**			
Hylobia spp.		foliage	occasional	native
Dermaptera	**Earwigs**			
Forficula auricularia	European earwig	omnivorous: leaves/flowers/fruit and insects	common	introduced
Hemiptera	**Bugs**			
Acanthosomatidae				
Oncacontias vittatus		sap feeder	occasional	native
Aphididae	**Aphids**			
Aulacorthum solani	foxglove aphid	sap feeder	occasional	introduced
Aphrophoridae	**spittle bugs**			
Carystoterpa vegans		sap feeder	occasional	native
Philaenus spumarius	meadow spittle bug	sap feeder	common	introduced
Cicadellidae	**leafhoppers**			
Batracomorphus sp.		sap feeder	occasional	
Cixiidae				
Oliarus oppositus		sap feeder	occasional	native
Koroana rufifrons		sap feeder	occasional	native

Taxon	Common Name	Feeding Site	Frequency	Origin
Flatidae	**planthoppers**			
Siphanta acuta	green planthopper	sap feeder	abundant	introduced
Lygaeidae	**seed bugs**			
Rhypodes sp.		sap/seed feeder	occasional	native
Membracidae				
Acanthucus trispinifer		sap feeder	occasional	introduced
Miridae	**mirid bugs**			
Chinamiris spp.		sap feeder	occasional	native
Diomocoris spp.		sap feeder	occasional	native
Sidnia kinbergi	Australian crop mirid	sap feeder	occasional	introduced
Pentatomidae	**shield bugs**			
Cuspicona simplex	green potato bug	sap feeder	occasional	introduced
Nizara viridula	green vegetable bug	sap feeder	common	introduced
Ricaniidae	**planthoppers**			
Scolypopa australis	passionvine hopper	sap feeder	abundant	introduced
Rhyparochromidae	**seed bugs**			
Metagerra sp.		sap/seed feeder	common	native
Targarema sp.		sap/seed feeder	occasional	native
Lepidoptera	**moths and butterflies**			
Noctuidae	**armyworms, cutworms**		all noctuid species combined – common	
Graphania ustistriga		foliage	occasional	native
unidentified Noctuidae		foliage	occasional	
Tortricidae	**leaf rollers**		all tortricid species combined – abundant	
Ctenopseustis obliquana or Ctenopseusti herana		foliage	common	native
Epalxiphora axenana	sharp-tipped bell moth	foliage	occasional	native
Epiphyas postvittana	light-brown apple moth	foliage	occasional	introduced
Planotortrix excessana or Planotortrix octo		foliage	occasional	native
unidentified Tortricidae		foliage	common	
Orthoptera	**crickets, grasshoppers, weta**			
Tettigoniidae	**long-horned grasshoppers**			
Caedicia simplex	katydid	foliage	common	native
Conocephalus sp.	field grasshopper	foliage	occasional	native
Thysanoptera	**thrips**			
Heliothrips haemorrhoidalis	greenhouse thrips	foliage	occasional	introduced

Taxon	Common Name	Feeding Site	Frequency	Origin
Hercinothrips bicinctus	banana silvering thrips	foliage	common	introduced
Thrips obscuratus	New Zealand flower thrips	flowers	common	native

Predators

Predatory species that may inhibit introduced biological control agents were recorded (Table 2 and Appendix 1).

Table 2. Predatory invertebrates collected from Japanese honeysuckle at 33 New Zealand sites during 2004–2005.

Taxon	Common Name	Frequency	Origin
Acarina	**mites and ticks**		
Anystidae			
Anystis baccarum	whirlygig mite	occasional	
Anystis sp.	whirlygig mite	common	introduced
Bdellidae			
unidentified Bdellidae		rare	
Cunaxidae			
unidentified Cunaxidae		rare	
Phytoseiidae			
Phytoseius sp.		occasional	
Stigmaedae			
Zetzellia maori		rare	
Araneida	**spiders**		
unidentified Araneida		abundant	native and introduced
Opiliones	**harvestmen**		
unidentified harvestmen		occasional	
Pseudoscorpiones	**pseudo-scorpions**		
unidentified pseudo-scorpions		occasional	
Insecta			
Coleoptera	**beetles**		
Cantharidae	**soldier beetles**		
Malthodes pumilus		rare	introduced
Carabidae	**ground beetles**		
Amarotypus edwardsii		rare	native
Demetrida lineella		occasional	native
Scopodes sp.		rare	native

Taxon	Common Name	Frequency	Origin
Cleridae	**checkered beetles**		
Phymatophaea sp.		rare	native
Coccinellidae	**ladybirds**	all coccinellid species combined – common	
Adalia bipunctata	two-spotted ladybird	occasional	introduced
Adoxellus sp.		rare	native
Coccinella undecimpunctata	eleven-spotted ladybird	occasional	introduced as a biocontrol agent (BCA)
Cryptolaemus montrouzieri	mealybug ladybird	rare	introduced (BCA)
Halmus chalybeus	steely-blue ladybird	occasional	introduced (BCA)
Rhyzobius sp.		rare	
Stethorus sp.		rare	
Melyridae	**flower beetles**		
unidentified Melyridae		common	native
Scirtidae	**marsh beetles**		
unidentified Scirtidae		abundant	native
Staphylinidae	**rove beetles**		
Anotylus sp.		rare	native
Astenus guttula		rare	introduced
unidentified Staphylinidae		occasional	
Dermaptera	**earwigs**		
Forficula auricularia	European earwig	common	introduced
Hemiptera	**bugs**		
Anthocoridae			
unidentified Anthocoridae		common	
Miridae	**mirid bugs**		
Deraecoris maoricus		occasional	native
Sejanus albisignatus		occasional	native
Nabidae			
Nabis biformis		common	native
Nabis sp.		occasional	
Pentatomidae	**shield bugs**		
Cermatulus nasalis	brown soldier bug	occasional	native
Oechalia schellenbergii	Schellenberg's soldier bug	occasional	native
Reduviidae	**assasin bugs**		
unidentified Reduviidae		occasional	
Hymenoptera	**bees, wasps, ants**		
Formicidae	**ants**		
Monomorium sp.		rare	

Taxon	Common Name	Frequency	Origin
Ochetellus glaber		rare	introduced
Paratrechina vaga	garden ant	common	introduced
Prolasius advena	small brown bush ant	rare	native
Tetramorium bicarinatum		occasional	introduced
Technomyrmex albipes	white-footed house ant	common	introduced
Mantodea	**praying mantids**		
Miomantis caffra	African praying mantis	common	introduced
Orthodera novaezealandiae	New Zealand praying mantis	common	native
Neuroptera	**lacewings**		
Micromus tasmaniae	Tasmanian lacewing	common	introduced
Psectra nakaharai		rare	introduced
Orthoptera	**crickets, grasshoppers, weta**		
Anostostomatidae			
Raphidophoridae	**cave weta**		
unidentified Raphidophoridae		rare	

Parasitoids

Parasitic species that may inhibit introduced biological control agents were recorded (Table 3 and Appendix 1).

Table 3. Parasitic invertebrates collected from invertebrate species associated with Japanese honeysuckle at 33 New Zealand sites during 2004–2005.

Taxon	Common Name	Frequency	Origin
Diptera	**flies**		
Tachinidae	**bristle flies**		
Pales funestra	NZ leafroller tachinid	rare	native
Trigonospila brevifacies	Australian leafroller tachinid	common	introduced as a biocontrol agent (**BCA**)
Hymenoptera	**bees, wasps, ants**		
Braconidae			
Dolichogenidea tasmanica		rare	introduced (**BCA**)
Glyptapanteles demeter		occasional	native
Meteorus pulchricornis		occasional	introduced
Eulophidae			
Sympiesis sp. 1 (of Berry)		occasional	
Sympiesis sp. (species with partially orange gaster)		occasional	

Taxon	Common Name	Frequency	Origin
Ichneumonidae			
Campoletis sp.		rare	native
Campoplex sp. 9 of Gauld		rare	native
Campoplex sp.		rare	native

5.2 Fungi

A low level of disease was observed on all plants sampled at all surveyed sites. Field observations were that symptoms were usually sporadic and superficial leaf necrosis that caused minor/insignificant damage to the weed. A total of 38 fungal species was identified from these mild to moderate necroses exhibited on Japanese honeysuckle in New Zealand. Three of these fungi were identified directly from symptomatic plant tissues with the remainder being isolated out from tissues into pure culture.

A total of 461 fungal isolates was obtained from 469 plant tissue plated. Fungal colonisation ([total number of fungal isolates/number of tissue fragments] × 100) averaged across all tissue types (leaf and flower) was 98.3%. The mean fungal colonisation observed for Japanese honeysuckle was at the high end of the range recorded from Landcare Research pathogen weed surveys. Other surveys that recorded similar high levels of fungal colonisation were of Darwin's barberry, *Berberis darwinii*, 98.4%; barberry, *B. glaucocarpa*, 95.7%) woolly nightshade, *Solanum mauritianum* (92%); nassella tussock, *Nassella trichotoma* (95%); and Chilean needle grass, *Nassella neesiana* (98%) (Smith et al. 2004).

A total of 59 recognisable taxonomic units (RTUs) was isolated into culture from symptoms of leaf or flower necrosis, with 35 identified to genus and/or species level (Table 4) based on cultural morphology. A large number of isolates (64), were classified into RTUs belonging to the sterile fungi class Agonomycetes (*Mycelia sterilia*), which does not form reproductive spores under culture conditions. Identification of these fungi would require molecular methods using, e.g., genetic ITS sequence data, but was unnecessary for the purposes of this survey as most were considered to be endophytes, weak/secondary pathogens or saprophytes (Table 4).

The most frequently encountered group of fungi isolated from diseased leaf tissues was the Coelomycetous fungi, generally associated with minor and superficial leaf spots collected from all 33 sites. A total of 230 Coelomycete isolates was obtained in pure culture (Table 4). These were *Colletotrichum gloeosporioides* (24 isolates), *Microsphaeropsis* sp. (11 isolates), *Pestalotiopsis* sp. (9 isolates), *Phoma* spp. (58 isolates), *Phomopsis* spp. (49 isolates), as well as a range of unidentified Coelomycetous isolates (79). Many of these were regarded as secondary pathogens or saprophytes as they were isolated from leaf spots caused by the primary infection of *Pseudocercospora lonicerae*.

The remainder of leaf isolates obtained in the survey were Hypomycetous species such as *Fusarium avenaceum* and *Botrytis cinerea*, which again were either weak or secondary pathogens (Table 4).

Disease damage observed on flower tissues was minimal; mainly comprising discolouration and browning along with the appearance of tiny speckled lesions. A total of 20 diseased

flower tissues was plated from 3 sites. The fungi isolated from diseased flowers at two locations were saprophytic species, (*Alternaria alternata, Aureobasidium pullulans, Epicoccum purpurascens, Penicillium* spp., Yeasts), and at the third location were a minor disease complex comprising weak/secondary pathogens already described from minor leaf spots (*Fusarium* sp., *Phoma* sp., *Phomopsis* sp.).

Table 4. Relative abundance of fungi collected from Japanese honeysuckle at 33 sites throughout New Zealand 2004–05. ([1] = number of sites where each fungi present, [2] = total no. of isolates, L[3]= + recorded from leaf/stem tissue, F[4]= + recorded from flower tissue)

Species	Sites [1]	Total [2]	L[3]	F[4]	Comments
Ascomycetes					
Apiospora montagnei	1	1	+		Saprophyte
Chaetomium globosum	2	2	+		Saprophyte
Basidiomycetes					
Aureobasidium pullulans	11	21	+	+	Saprophyte
Chondrostereum purpureum	1	*			Primary pathogen Broad host range Virulent pathogen successfully used for the inundative biocontrol of invasive shrub/tree species
Coelomycetes					
Pseudocercospora lonicerae	29	*	+		Primary pathogen
Colletotrichum gloeosporioides	15	24	+		Primary and secondary plant pathogen Broad host range Virulent host specialised strains are known to exist on some plant hosts and have been successfully used for weed biocontrol
Microsphaeropsis sp.	8	11	+		Weak or secondary pathogen Broad host range
Pestalotiopsis sp.	4	9	+		Primary and secondary plant pathogen Broad host range
Phoma spp. (>7 species isolated)	16	58	+	+	Saprophytes Primary and secondary plant pathogen Broad host range Virulent strains have been used successfully for

Species	Sites [1]	Total [2]	L [3]	F [4]	Comments
					weed biocontrol
Phomopsis sp. (2 species isolated)	22	49	+	+	Primary and secondary plant pathogen Broad host range
unidentified Coelomycete spp.	26	79	+		Weak or secondary pathogens and/or saprophytes
Hyphomycetes					
Acremonium spp. (2 species isolated)	4	4	+		Saprophyte Secondary plant pathogen
Alternaria alternata	14	40	+	+	Saprophyte Secondary plant pathogen Broad host range
Botrytis cinerea	9	19	+		Saprophyte Primary and secondary plant pathogen Broad host range
Cladosporium cladosporioides	11	16	+		Saprophyte
Epicoccum purpurascens	10	22	+	+	Saprophyte
Fusarium spp. (6 species isolated)	14	26	+	+	Primary and secondary plant pathogens Broad host range Some species have previously been investigated for weed biocontrol
Gyoerffyella rotula	1	2	+		Weak or secondary pathogen
Penicillium spp. (>4 species isolated)	5	6	+	+	Saprophytes
Trichoderma sp.	1	1	+		Saprophyte
Xylaria spp. (2 species isolated)	3	5	+		Endophytic symbiont of many plant hosts

Species	Sites [1]	Total [2]	L [3]	F [4]	Comments
Other					
Insolibasidium deformans	1	*	+		Obligate primary pathogen of *Lonicera* genus, also known as Honeysuckle leaf blight
Sterile fungi (*Mycelia sterilia*)	19	64	+		Endophytic symbionts, saprophytes or weakly pathogenic
unidentified yeast	1	1		+	Saprophyte
Zygomycetes					
Mortierella gamsii	1	1	+		Saprophyte

* Although *Pseudocercospora lonicerae*, *Chondrostereum purpureum* and *Insolibasidium deformans*, were collected and identified, none were isolated into culture and they are therefore not included in the total number of isolates tally.

The most common leaf spot damage on Japanese honeysuckle was that caused by *Pseudocercospora lonicerae*, which was observed on samples from 29 of the 33 sites surveyed. Its initial symptom was a characteristic brown circular spot at the leaf edge. As the disease progressed the lesion increased in size, spreading from the leaf margin, and becoming irregular shaped. Surrounding leaf tissue then became discoloured, turning yellow until the entire leaf was discoloured and dry (Fig. 2). A representative specimen exhibiting these symptoms was deposited into Landcare Research's PDD Herbarium collection at Auckland (Herbarium accession number = PDD 82491).

Fig. 2 Progression of leaf disease on Japanese honeysuckle caused by *Pseudocercospora lonicerae.*

Basidiocarps of *Chondrostereum purpureum* were collected from the basal stem of a Japanese honeysuckle vine (Fig. 3) at a single site at Waipu Gorge, Northland (Site 3, Fig. 1). There were no visible signs that infection by this pathogen had reduced the growth or health of this plant at the time of collection. Despite several attempts to isolate the pathogen onto Nobles agar, no cultures were obtained.

Samples exhibiting a fungal leaf blight disease from a single site, in the Auckland region, were also observed in the survey. The disease was identified as *Insolibasidium deformans*, which is commonly known as honeysuckle blight. Blight symptoms recorded from these

samples were that infected younger leaves showed a silvery-white discolouration. Discolouration had progressed on older infected leaves turning them tan to brown. These brown areas often covered the entire leaf and were necrotic and dry.

Fig. 3 Fruiting body (basidiocarp) of *Chondrostereum purpureum* on the excised vine of Japanese honeysuckle collected from Northland.

6. Conclusions

6.1 Invertebrates

A wide range of native and introduced invertebrates is associated with Japanese honeysuckle in New Zealand but no specialised Japanese honeysuckle feeding invertebrates were found during this survey**,** and damage caused by invertebrate herbivory could not be regarded as serious. Foliage feeders (most noticeably lepidopterous larvae, molluscs and thrips) appear to be the most damaging invertebrates currently feeding on Japanese honeysuckle in New Zealand.

The total amount of Japanese honeysuckle foliage that appeared to have been consumed or damaged by herbivorous invertebrates at our survey sites was estimated to be less than 5%. As a comparison, the amounts of foliage estimated to have been consumed or damaged by herbivorous invertebrates for other weeds in New Zealand are: less than 10% for banana passionfruit, probably mainly by lepidopterous larvae (Winks & Fowler 2000); less than 5% for boneseed, mostly attributed to two weevil species – *Phlyctinus callosus* and, to a lesser extent, *Asynonychus cervinus* (Winks et al. 2000); less than 5% for woolly nightshade, probably mainly by lepidopterous larvae (Winks et al. 2001); less than 2% for tradescantia (Winks et al. 2003); and less than 2% for moth plant (Winks et al. 2004).

The combined effect of generalist predators such as spiders, earwigs, ants, and praying mantids, could inhibit the effectiveness of some potential invertebrate biological control agents for Japanese honeysuckle. The parasitoids identified during this survey could particularly affect some potential lepidopteran biological control agents.

Specialised Japanese honeysuckle biocontrol agents are unlikely to meet with any significant competition from resident herbivores as none of the 'herbivore niches' on Japanese honeysuckle are well utilised in New Zealand, and some (e.g., leaf-mining) do not appear to be utilised at all. Therefore there is considerable scope for the introduction of host-specific invertebrate biocontrol agents that could markedly reduce the vigour of Japanese honeysuckle in New Zealand.

6.2 Fungi

Although honeysuckle blight, *Pseudocercospora lonicerae*, was widespread in distribution, leaf damage to Japanese honeysuckle infestations was limited and did not reduce plant health to any useful extent. Its biocontrol potential is therefore considered to be low. This pathogen has been recorded from Japanese honeysuckle four times previously on the target weed in New Zealand (NZ Fungi Database http://nzfungi.landcareresearch.co.nz/ data retrieved 29 August 2005), but associated symptoms were also minor leaf spot damage (Braun et al. 2003) and therefore biocontrol potential of endemic strains is similarly regarded to be low. This pathogen was listed as a known leaf spot pathogen of Japanese honeysuckle in North America and a potential candidate for classical biocontrol prior to this survey (Standish 2002). However, as the strain(s) currently in New Zealand appear to be weakly pathogenic, surveys in the native range would be needed to determine if more aggressive biotypes of this pathogen are present, and are likely to be possible candidates for importation to augment the endemic strains already present on the target.

The observation of *Chondrostereum purpureum* on Japanese honeysuckle in this survey is a new host record for this pathogen in New Zealand, and possibly also a new international record. The pathogen has, however, been reported on other *Lonicera* species (Setcliff 2002), including the shrubby relative *L. tatarica* in New Zealand (Pennycook 1989). This fungus is a widespread wound pathogen, commonly known as silver leaf disease, and is a serious horticultural disease as it has a broad host range across many woody plant species including those of economic and cultivated importance, e.g., *Malus*, apple; *Prunus*, stonefruit; *Magnolia* (Farr et al. 1989). Despite this, the fungus has also been successfully used and registered as a 'cut and paste' mycoherbicide against resprouting tree weeds in North America, South Africa and Europe, and has also been used against gorse in New Zealand. The application of *C. purpureum* for inundative biocontrol of Japanese honeysuckle would be minimal and logistically difficult as its pathogenicity is limited to wounded woody tissues so

could only possibly be used to prevent resprouting from old mature vines that were being cut back during physical weed removal (which is not the conventional control strategy currently used for most environmental infestations). It would not be effective against the rapid invasion of herbaceous Japanese honeysuckle vines in many areas.

The observation of honeysuckle leaf blight caused by *Insolibasidium deformans* in this survey was to be expected as it is a ubiquitous pathogen with a worldwide distribution. Most known species and varieties in the honeysuckle (*Lonicera*) genus are susceptible to the blight. It has been recorded three times previously on Japanese honeysuckle in New Zealand as well as on *L. tatarica* (Pennycook 1989) and recently in Australia on *L. nitida* (Cunnington & Pascoe 2003). The blight is a major problem for cultivation of seedlings causing significant economic problems to the nursery and garden industry in North America where honeysuckle is an important ornamental plant (Beales et al. 2004). Infected seedlings become discoloured and defoliate prematurely. Severe defoliation results in stem dieback and reduced growth so that stock may have to be retained in the nursery for an additional year.

Honeysuckle blight is totally reliant on climatic conditions being both cool and wet, as the infection only occurs when the relative humidity is near or at 100% during sustained periods for at least 2 days, and where the leaves are less than 20 days old. The disease will continue throughout the growing season only if conducive weather is present.

The biocontrol potential of this disease is low as attack on adult plants is sporadic due to its requirement for a relatively narrow range of climatic conditions. Therefore the disease will rarely be able to undertake sustained attack at an effective level on the weed in its current expanding range across all regions.

As flower damage was minimal, with mostly saprophytic species, e.g., yeasts, being associated with very minor symptoms, it was likely that damage was not caused by premature infection by a primary pathogen but rather due entirely to natural senescence of the delicate flower tissues.

Leaf disease was also observed to be very minor caused by a sporadic range of minor primary pathogens and/or secondary pathogens. Coelomycetes, such as *Phoma* and *Phomopsis*, were generally the cause of such leaf spot symptoms, and these have been previously reported on Japanese honeysuckle both in New Zealand (e.g., *Phoma*, NZ Fungi Database http://nzfungi.landcareresearch.co.nz/ data retrieved 29 August 2005) and overseas (e.g., *Phomopsis* leaf spot in North America, Farr et al. 1989). Such superficial and almost cosmetic damage would not significantly reduce plant growth, biomass or reproduction, and therefore none of the isolated fungi would have potential for effective biocontrol.

7. Recommendations

In light of our conclusions that invertebrate herbivore damage to Japanese honeysuckle in New Zealand is not serious, and that no specialised pathogenic fungi are known to be present on the weed in New Zealand, we recommend that:

1. A classical biological control programme for Japanese honeysuckle should proceed as follows:

   (a) Survey herbivorous invertebrates and fungi associated with Japanese honeysuckle in its native range.

   (b) Prioritise potential biocontrol agents according to their potential to damage Japanese honeysuckle and the likelihood of adequate host-specificity.

   (c) Undertake host-range tests with selected invertebrates and fungi on plant species of importance to New Zealand.

   (d) Introduce host-specific invertebrates and pathogenic fungi to New Zealand as classical biocontrol agents.

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Appendix 1 Invertebrates associated with Japanese honeysuckle, *Lonicera japonica*, at 33 New Zealand sites (2004–2005)

Key: Definitions of frequency categories

rare: fewer than 5 individuals collected in total
occasional: 5–24 individuals collected, **or** present at fewer than five sites
common: 25+ individuals collected **and** present at five or more sites
abundant: 200+ individuals collected **and** present at 10 or more sites

Taxon	Common Name	Feeding Mode	Frequency and (total number)	Collection Sites
Phylum Mollusca	**molluscs**			
Class Gastropoda	**slugs and snails**			
Cantareus asperses Müller	brown garden snail	herbivorous	common (186)	2,6,9,10,11,12,13, 14,15,16,17,18,19, 20,21,22,23,29
unidentified snails		herbivorous	common (51)	1,2,3,4,9,11,12,14, 16,26,27,30,32,33
unidentified slugs		herbivorous	occasional (20)	12,14,15,17,22,25, 31,32,33
Phylum Arthropoda				
Class Crustacea				
Amphipoda				
unidentified Amphipoda		saprophytic	rare (2)	31
Isopoda	**slaters**			
unidentified Isopoda		saprophytic	abundant (380)	2,4,5,7,9,10,12,13, 15,16,18,26,31
Class Arachnida				
Acarina	**mites and ticks**			
Anystidae				
Anystis baccarum (Linnaeus)	whirlygig mite	predatory	occasional (12)	1,11,15,16,19
Anystis sp.	whirlygig mite	predatory	common (30)	9,17,19,24,29

Taxon	Common Name	Feeding Mode	Frequency and (total number)	Collection Sites
Bdellidae				
unidentified Bdellidae		predatory	rare (3)	3
Cunaxidae				
unidentified Cunaxidae		predatory	rare (4)	10,13
Phytoseiidae				
Phytoseius sp.		predatory	occasional (8)	10,21
Stigmaedae				
Zetzellia māori Gonzalez-Rodriguez		predatory	rare (1)	13
Tenuipalpidae	**false spider mites**			
unidentified Tenuipalpidae		herbivorous	rare (2)	10
Tetranychidae	**spider mites**			
Bryobia sp.		herbivorous	rare (1)	3
Tydeidae				
Orthotydeus californicus (Banks)		herbivorous	occasional (14)	9,10,12,21
unidentified Tydeidae		herbivorous	rare (3)	11
Oribatida	**oribatid mites**			
unidentified Oribatida		fungivorous	rare (2)	9
Araneida	**spiders**			
unidentified Araneida		predatory	abundant (667)	1,2,3,4,5,6,7,8,9, 10,11,12,13,14,15, 16,17,18,19,20,21, 22,23,24,25,26,27, 29,30,31,32,33

Taxon	Common Name	Feeding Mode	Frequency and (total number)	Collection Sites
Opiliones	**harvestmen**			
unidentified Opiliones		predatory	occasional (10)	13,17,18,20,31,33
Pseudoscorpiones	**false scorpions**			
unidentified Pseudoscorpiones		predatory	occasional (14)	2,3,8,22,31
Class Diplopoda	**millipedes**			
unidentified Diplopoda		saprophytic	rare (1)	17
Class Collembola	**springtails**			
unidentified Collembola		saprophytic	occasional (14)	3,16,17,30
Class Insecta	**insects**			
Blattodea	**cockroaches**			
Celatoblatta vulgaris Johns		saprophytic	rare (4)	14,18,25
Celatoblatta sp.		saprophytic	common (156)	3,4,6,8,9,10,11,12, 13,14,15,16,17,18, 19,22,23,24,26,27, 31,32,33
Celeriblattina major Johns		saprophytic	occasional (10)	7
Celeriblattina sp.		saprophytic	rare (1)	7,11,16,17
Drymaplaneta semivitta (Walker)	Gisborne cockroach	saprophytic	rare (4)	17
Drymaplaneta sp.		saprophytic	rare (1)	17
Parellipsidion latipennis (Brunner von Wattenwyl)		saprophytic	occasional (8)	7,16,17
Parellipsidion sp.		saprophytic	common (74)	5,7,11,13,16,17

Taxon	Common Name	Feeding Mode	Frequency and (total number)	Collection Sites
Coleoptera	**beetles**			
Anthicidae	**ant beetles**			
Macratria sp.		saprophytic	rare (1)	3
Sapintus deitzi Werner and Chandler		saprophytic	rare (2)	2
Sapintus pellucidipes (Broun)		saprophytic	occasional (12)	3,9,13,22,23,25,26
Sapintus sp.		saprophytic	occasional (16)	3,9,14
Anthribidae	**fungus weevils**			
Euciodes suturalis Pascoe		fungivorous	rare (1)	4
Sharpius brouni (Sharp)		fungivorous	occasional (7)	3,7,9,12,27
Cantharidae	**soldier beetles**			
Malthodes pumilus (Brebisson)		predatory	rare (1)	5
Carabidae	**ground beetles**			
Amarotypus edwardsii Bates		predatory	rare (2)	26
Demetrida lineella White		predatory	occasional (12)	23,26,27,29,30,31
Scopodes sp.		predatory	rare (1)	17
Cerambycidae	**longhorn beetles**			
Bethelium signiferum (Newman)	wattle longhorn	herbivorous	rare (1)	9
Coptomma sulcatum (Fabricius)		herbivorous	rare (2)	23
Hybolasius crista (Fabricius)		herbivorous	occasional (6)	5,8
Hybolasius vegetus Broun		herbivorous	rare (1)	21
Hybolasius sp.		herbivorous	rare (1)	27

Taxon	Common Name	Feeding Mode	Frequency and (total number)	Collection Sites
Microlamia pygmaea Bates		herbivorous	rare (1)	2
Oemona hirta (Fabricius)	lemon tree borer	herbivorous	rare (1)	1
Psilocnaeia spp.		herbivorous	occasional (17)	1,2,8,13,16,21, 22,23,30
Xuthodes punctipennis Pascoe	speckled longhorn	herbivorous	rare (1)	9
Xylotoles griseus (Harris)		herbivorous	occasional (10)	6,7,8,11,18,22,23, 29
Xylotoles griseus (Harris) or *Xylotoles laetus* White		herbivorous	occasional (6)	8,11,16,17
Xylotoles spp.		herbivorous	rare (4)	3,5,13,22
Zorion spp.	flower longhorn	herbivorous	rare (3)	8,27
Chrysomelidae	**leaf beetles**			
Dicranosterna semipunctata (Chapuis)		herbivorous	rare (1)	9
Eucolaspis sp.	bronze beetle	herbivorous	common (134)	1,5,7,8,22,23,24, 25,27,29
Peniticus sp.		herbivorous	rare (2)	19
Trachytetra rugulosa (Broun)		herbivorous	rare (1)	8
Ciidae				
Orthocis undulates (Broun)		fungivorous	rare (1)	8
Cleridae	**checkered beetles**			
Phymatophaea sp.		predatory	rare (2)	23,27
Coccinellidae	**ladybirds**			
Adalia bipunctata (Linnaeus)	two-spotted ladybird	predatory	occasional (6)	8,10,16,19

Taxon	Common Name	Feeding Mode	Frequency and (total number)	Collection Sites
Adoxellus sp.		predatory	rare (2)	14,29
Coccinella undecimpunctata Linnaeus	eleven-spotted ladybird	predatory	occasional (10)	4,6,8,12,16,18,20, 26
Cryptolaemus montrouzieri Mulsant	mealybug ladybird	predatory	rare (1)	9
Halmus chalybeus (Boisduval)	steely-blue ladybird	predatory	occasional (14)	6,7,10,11,14,16,24
Rhyzobius sp.		predatory	rare (3)	2,9,25
Stethorus sp.		predatory	rare (2)	3,13
Corylophidae	**hooded beetles**			
Sericoderus sp.		fungivorous	occasional (9)	1,2,12,13,17,27
Cryptophagidae	**cryptic beetles**			
Cryptophagus sp.		fungivorous	rare (1)	30
Micrambina spp.		pollen/fungus feeder	common (56)	6,9,10,12,13,18,22, 23,25,26,31
Paratomaria spp.		pollen/fungus feeder	abundant (403)	1,3,14,17,19,20,22, 24,25,26,27,29,30, 31,32,33
Curculionidae	**weevils**			
Asynonychus cervinus (Boheman)	Fuller's rose weevil	herbivorous	common (55)	7,8,10,15,18,26
Catoptes spp.		herbivorous	common (38)	14,16,29,30,31,32, 33
Didymus sp.		herbivorous	rare (2)	26,33
Irenimus spp.		herbivorous	common (29)	2,9,12,13,14,16,17, 18,22,26,30
Microcryptorhynchus sp.		herbivorous	occasional (5)	8,9,32

Taxon	Common Name	Feeding Mode	Frequency and (total number)	Collection Sites
Microtribus huttoni Wollaston		herbivorous	rare (1)	16
Otiorhynchus ovatus (Linnaeus)		herbivorous	rare (1)	30
Otiorhynchus rugosostriatus (Goeze)		herbivorous	rare (1)	4
Pactola sp.		herbivorous	rare (1)	33
Peristoreus spp.		herbivorous	occasional (5)	16,24,32
Phlyctinus callosus Boheman	garden weevil	herbivorous	occasional (10)	13,18,20
Praolepra sp.		herbivorous	rare (4)	1,5
Rhopalomerus spp.		pollen feeder	rare (3)	27,29
Sericotrogus subaenescens Wollaston		larvae and adults in dead wood	occasional (20)	1,2,7,8,9,16,18
Sitona discoideus Gyllenhal	sitona weevil	herbivorous	rare (1)	16
Sitona lepidus Gyllenhal	clover root weevil	herbivorous	rare (2)	15,18
Sphenophorus brunnipennis (Germar)		herbivorous	rare (1)	2
Stephanorhynchus curvipes White		herbivorous/ pollen feeder	rare (3)	7
Unidentified Cossinae			rare (1)	16
Dermestidae	**hide beetles**			
Trogoderma sp.		pollen feeder	rare (1)	2
Elateridae	**click beetles**			
Conoderus exsul (Sharp)	pasture wireworm	herbivorous	common (30)	4,6,7,9,11,14,15,16
Metablax cinctiger (White)		herbivorous	rare (1)	9
Elmidae				
Hydora sp.		herbivorous	rare (1)	10

Taxon	Common Name	Feeding Mode	Frequency and (total number)	Collection Sites
Erotylidae	**handsome fungus beetles**			
Loberus depressus (Sharp)		saphrophytic	rare (2)	2
Loberus nitens (Sharp)		saphrophytic	rare (1)	16
Latridiidae	**mildew beetles**			
Aridius bifasciatus (Reitter)		fungivorous	common (27)	3,9,10,12,13,16,17, 18,19,32
Aridius nodifer (Westwood)		fungivorous	occasional (5)	1,17
Melanophthalma sp.		fungivorous	common (183)	1,2,3,10,11,12, 13,15,16,17,18,19, 22,23,24,31
Rethusus sp.		fungivorous	rare (1)	3
unidentified Latridiidae		fungivorous	occasional (17)	6,8,17,19,21,22,23
Lycidae	**net winged beetles**			
Porrostoma rufipenne (Fabricius)		adults: nectar and pollen	rare (1)	7
Melandryidae	**leaping beetles**			
Hylobia plagiata Broun		herbivorous	rare (1)	33
Hylobia spp.		herbivorous	occasional (9)	9,10,15,18,32
Melyridae	**flower beetles**			
unidentified Melyridae		predatory	common (43)	2,22,24,28,29
Mordellidae	**pintail beetles**			
Mordella jucunda (Broun)		herbivorous	rare (1)	20
Stenomordellaria neglecta (Broun)		herbivorous	rare (1)	28

Taxon	Common Name	Feeding Mode	Frequency and (total number)	Collection Sites
Zeamordella monacha Broun		herbivorous	rare (1)	7
Mycetophagidae	**fungus beetles**			
Litargus vestitus (Sharp)		fungivorous	occasional (5)	12,16,18
Triphyllus hispidellus (Broun)		fungivorous	rare (2)	5
Nitidulidae	**sap beetles**			
Aethina nigra (Reitter)		pollen feeder	occasional (5)	6
Salpingidae	**bark mould beetles**			
Salpingus bilunatus Pascoe		fungivorous	rare (1)	9
Salpingus sp.		fungivorous	rare (3)	7,10,14
Scarabaeidae	**scarab beetles**			
Odontria sp.		herbivorous	rare (1)	10
Scraptiidae	**soft leaping beetles**			
Nothotelus sp.		herbivorous	rare (2)	24,29
Scirtidae	**marsh beetles**			
unidentified Scirtidae		predatory	abundant (293)	1,2,3,5,7,8,9,15,19, 20,21,22,23,24,27, 28,32,33
Silvanidae	**flat beetles**			
Cryptamorpha desjardinsi (Guérin)	Desjardin's flat beetle	fungivorous	rare (1)	12
Cryptamorpha brevicornis (White)	shorthorned flat beetle	fungivorous	rare (1)	10
Staphylinidae	**rove beetles**			
Anotylus sp.		predatory	rare (1)	17
Astenus guttula Fauvel		predatory	rare (1)	11

Taxon	Common Name	Feeding Mode	Frequency and (total number)	Collection Sites
unidentified Staphylinidae		predatory	occasional (8)	15,16
Tenebrionidae	**darkling beetles**			
Lorelus sp.		herbivorous	rare (2)	6
Zopheridae	**false darkling beetles**			
Bitoma insularis White		herbivorous	rare (1)	2
Tarphiomimus indentatus Wollaston		herbivorous	rare (1)	4
Dermaptera	**earwigs**			
Forficula auricularia Linnaeus	European earwig	omnivorous	common (45)	5,8,9,10,11,12,13, 15,16,18,20,21,23
Diptera	**flies**			
Bibionidae	**March flies**			
Dilophus nigrostigma (Walker)	blossom fly	adults: nectar and pollen	rare (4)	5,19,22,24
Stratiomyidae	**soldierflies**			
Unidentified Stratiomyidae		adults: nectar and pollen	rare (1)	27
Tachinidae	**bristle flies**			
Pales funestra (Hutton)	New Zealand leafroller tachinid	parasitoid	rare (4)	26,33
Trigonospila brevifacies (Hardy)	Australian leafroller tachinid	parasitoid	common (27)	4,6,9,10,11,14,18, 30
Hemiptera	**bugs**			
Acanthosomatidae				
Oncacontias vittatus (Fabricius)		sap feeder	occasional (37)	26,32
Rhopalimorpha lineolaris Pendergrast		sap feeder	rare (2)	5,23
Anthocoridae				
unidentified Anthocoridae		predatory	common	1,3,6,8,9,10,11,12, 13,14,17,19,20,23,

Taxon	Common Name	Feeding Mode	Frequency and (total number)	Collection Sites
			(53)	26,31,32
Aphididae	**aphids**			
Aulacorthum solani (Kaltenbach)	foxglove aphid	sap feeder	occasional (7)	7,21
Aphrophoridae	**spittle bugs**			
Carystoterpa fingens (Walker)		sap feeder	rare (2)	7,9
Carystoterpa vegans Hamilton and Morales		sap feeder	occasional (8)	19,32
Philaenus spumarius (Linnaeus)	meadow spittle bug	sap feeder	common (43)	9,11,17,18,19,20, 21,23,24,28,29,30, 32,33
Berytidae				
Bezu wakefieldi (White)		sap feeder	rare (4)	9,22
Cicadellidae	**leafhoppers**			
Batracomorphus sp.		sap feeder	occasional (25)	8,19
Limotettix sp.		sap feeder	rare (1)	9
Nesoclutha pallida (Evans)		sap feeder	rare (2)	9,11
Cixiidae				
Aka duniana (Myers)		sap feeder	rare (3)	24
Aka westlandica Larivière		sap feeder	rare (1)	32
Cixius sp.		sap feeder	rare (2)	3
Oliarus oppositus (Walker)		sap feeder	occasional (10)	7,9,20,22
Koroana rufifrons (Walker)		sap feeder	occasional (10)	3,7,22,28
Coccidae	**soft scales**			
Saissetia oleae (Olivier)	olive scale	sap feeder	rare (2)	7

Taxon	Common Name	Feeding Mode	Frequency and (total number)	Collection Sites
Coreidae				
Acantholybas brunneus (Breddin)		sap feeder	rare (2)	2,5
Delphacidae				
Anchodelphax sp.		sap feeder	rare (4)	9,12,18
Ugyops sp.		sap feeder	rare (2)	2,11
Flatidae	**planthoppers**			
Anzora unicolor (Walker)	grey planthopper	sap feeder	rare (3)	17,25,30
Siphanta acuta (Walker)	green planthopper	sap feeder	abundant (379)	5,6,7,8,9,10,11,12, 13,16,17,18,19,21, 22,23,24,25,26,27, 29,31
Lygaeidae	**seed bugs**			
Rhypodes sp.		sap/seed feeder	occasional (6)	6,9,15,24
Membracidae				
Acanthucus trispinifer (Fairmaire)		sap feeder	occasional (25)	32
Miridae	**mirid bugs**			
Chinamiris spp.		sap feeder	occasional (48)	24
Deraecoris maoricus Woodward		predatory	occasional (8)	14,31,32
Diomocoris sp.		sap feeder	occasional (22)	7,8,24
Halormus velifer Eyles & Schuh		sap feeder	rare (4)	8
Sejanus albisignatus (Knight)		predator/pollen feeder	occasional (6)	11,24
Sidnia kinbergi (Stål)	Australian crop mirid	sap feeder	occasional (6)	10,14,16,19,24
Stenotus binotatus (Fabricius)	slender crop mirid	sap feeder	rare (2)	20
Xiphoides sp.		sap feeder	rare (2)	27
unidentified Orthotylinae			rare (1)	19

Taxon	Common Name	Feeding Mode	Frequency and (total number)	Collection Sites
unidentified Miridae			occasional (31)	2,5,9,20
Nabidae	**damsel bugs**			
Nabis biformis (Bergroth)		predatory	common (44)	7,8,9,10,27,28
Nabis sp.		predatory	occasional (6)	2,19,22
Pentatomidae	**shield bugs**			
Cermatulus nasalis (Westwood)	brown soldier bug	predatory	occasional (9)	8,17,18,32
Cuspicona simplex Walker	green potato bug	sap feeder	occasional (16)	3,8,17,21,25,33
Dictyotus caenosus (Westwood)	brown shield bug	sap feeder	rare (4)	11,19
Glaucias amyoti (Dallas)	New Zealand vegetable bug	sap feeder	rare (3)	16
Nizara viridula (Linnaeus)	green vegetable bug	sap feeder	common (125)	2,4,5,6,7,9,10,11, 12,13,14,15,16,17
Oechalia schellenbergii (Guérin)	Schellenberg's soldier bug	predatory	occasional (12)	11,15
Reduviidae	**assasin bugs**			
unidentified Reduviidae		predatory	occasional (11)	8,19
Ricaniidae	**planthoppers**			
Scolypopa australis (Walker)	passionvine hopper	sap feeder	abundant (2000 plus)	4,6,8,9,10,11,12, 13,15,16,17,18,24, 25,26,30
Rhyparochromidae	**seed bugs**			
Margareta dominica White		sap/seed feeder	rare (2)	13
Metagerra sp.		sap/seed feeder	common (34)	14,17,21,22,27,28, 29
Remaudiereana sp.		sap/seed feeder	rare (1)	2
Targarema sp.		sap/seed feeder	occasional (5)	14,17,22

Taxon	Common Name	Feeding Mode	Frequency and (total number)	Collection Sites
Hymenoptera	**bees, wasps, ants**			
Braconidae	**parasitic wasps**			
Dolichogenidea		parasitoid	rare	12,20,21,22
tasmanica Cameron			(4)	
Glyptapanteles demeter (Wilkinson)		parasitoid	occasional (88)	4,9,20,21
Meteorus pulchricornis Wesmael		parasitoid	occasional (16)	6,9,10,13,14,15,17, 18,20,21,23,27,32
Eulophidae				
Sympiesis sp. 1 (of Berry)		parasitoid	occasional (25)	31
Sympiesis sp. (species with partially orange gaster)		parasitoid	occasional (6)	26
Formicidae	**ants**			
Monomorium sp.		omnivorous	rare (2)	2,7
Ochetellus glaber (Mayr)		omnivorous	rare (1)	2
Paratrechina vaga (Forel)	garden ant	omnivorous	common (27)	1,2,8,12,23
Prolasius advena (Smith)	small brown bush ant	omnivorous	rare (4)	10,13
Tetramorium bicarinatum (Nylander)		omnivorous	occasional (10)	8
Technomyrmex albipes (Smith)	white-footed house ant	omnivorous	common (109)	1,2,5,6,7,9,12,17, 21
Ichneumonidae				
Campoletis sp.		parasitoid	rare (1)	8
Campoplex sp. 9 of Gauld		parasitoid	rare (1)	9
Campoplex sp.		parasitoid	rare (2)	31,32
Lepidoptera	**moths and butterflies**			
(collected as larvae and reared to adult for identification)				
Elachistidae				
Elachista archaeonoma Meyrick		herbivorous	rare (1)	2

Taxon	Common Name	Feeding Mode	Frequency and (total number)	Collection Sites
Geometridae	**looper moths**			
Gellonia dejectaria Walker	brown evening moth	herbivorous	rare (1)	22
Gellonia pannularia Guenee		herbivorous	rare (1)	1
Homodotis megaspilata Walker		herbivorous	rare (2)	3,24
Phrissogonus laticostatus Walker	feathered moth	herbivorous	rare (1)	18
Pseudocoremia suavis Butler	common forest looper	herbivorous	rare (1)	22
unidentified Geometridae		herbivorous	rare (4)	6,21,23
Noctuidae	**armyworms, cutworms**			
Chrysodeixis eriosoma (Doubleday)	green looper or silver Y moth	herbivorous	rare (2)	2,13
Feredayia graminosa (Walker)	mahoe stripper	herbivorous	rare (1)	21
Graphania ustistriga Walker		herbivorous	occasional (8)	3,5,9,21,23,27
Graphania sp.		herbivorous	rare (1)	31
Rhapsa scotosialis Walker	slender owlet	herbivorous	rare (1)	32
unidentified Noctuidae		herbivorous	occasional (23)	5,7,9,10,11,12,18, 21,23,24,26,31
Psychidae	**bag moths**			
Lepidoscia heliochares Meyrick	thatched cottage	herbivorous (algal feeder)	rare (1)	14
Lepidoscia lainodes Meyrick	little log cabin bag moth	herbivorous (algal feeder)	rare (3)	15
Thyrididae				
Morova subfasciata Walker		gall-former on *Meuhlenbeckia* sp.	rare (1)	24
Tortricidae	**leaf rollers**			
Apoctena orthropis Meyrick		herbivorous	rare (1)	29

Taxon	Common Name	Feeding Mode	Frequency and (total number)	Collection Sites
Cnephasia jactatana Walker	black-lyre moth	herbivorous	rare (3)	8,9
Ctenopseustis obliquana (Walker) **or** *C. herana* (Felder and Rogenhofer)		herbivorous	common (66)	1,3,5,7,8,9,11,18, 20,22,23,24,26,30, 31,32,33
Epalxiphora axenana Meyrick	sharp-tipped bell moth	herbivorous	occasional (6)	9,31,33
Epiphyas postvittana (Walker)	light-brown apple moth	herbivorous	occasional (9)	1,4,5,7,9,12,21,28
Planotortrix excessana Walker **or** *P. octo* Dugdale		herbivorous	occasional (18)	8,18,20,23,25,26, 30,31,32,33
Pyrgotis plagiatana Walker	painted wedge	herbivorous	rare (1)	33
unidentified Tortricidae		herbivorous	common (134)	4,6,8,9,10,11,12, 13,14,15,16,17,18, 20,21,22,26,27,31, 32,33
Mantodea	**praying mantids**			
Miomantis caffra Saussure	African praying mantis	predatory	common (47)	1,4,6,7,10,11,13, 14,16,17,18
Orthodera novaezealandiae (Colenso)	New Zealand praying mantis	predatory	common (29)	6,7,9,10,11,12,16
Neuroptera	**lacewings**			
Micromus tasmaniae (Walker)	Tasmanian lacewing	predatory	common (110)	4,5,7,8,9,10,11,13, 15,16,17,19,20,22, 24,26,29,30,31,32, 33
Psectra nakaharai New		predatory	rare (1)	30
Orthoptera	**crickets, grasshoppers, weta**			
Anostostomatidae				
Hemideina sp.		omnivorous	rare (2)	23
Grillidae				
Bobilla sp.		herbivorous	rare (1)	33

Taxon	Common Name	Feeding Mode	Frequency and (total number)	Collection Sites
Raphidophoridae	**cave weta**			
unidentified Raphidophoridae		omnivorous	rare (4)	1,3,13,18
Tettigoniidae	**long-horned grasshoppers**			
Caedicia simplex (Walker)	katydid	herbivorous	common (52)	4,5,6,7,8,10,11,12, 13,14,15,17,18,21, 22,23,25,30
Conocephalus sp.	field grasshopper	herbivorous	occasional (15)	1,2,4,7,9,11,12,13, 15,17,18,19,20,22
Psocoptera	**book lice**			
unidentified Psocoptera		saprophytic and fungivorous	common (35)	2,6,7,8,9,13,15,16, 17,18,21,30,31,32
Thysanoptera	**thrips**			
sub-order Terebrantia				
Thripidae				
Heliothrips haemorrhoidalis (Bouche)	greenhouse thrips	herbivorous	occasional (46)	5,6,10,17
Hercinothrips bicinctus (Bagnall)	banana silvering thrips	herbivorous	common (118)	4,11,12,16,20,21
Thrips obscuratus (Crawford)	New Zealand flower thrips	herbivorous	common (163)	1,3,5,6,14,19,20, 21,22,23,24,27,29, 30,31
sub-order Tubulifera				
unidentified Tubulifera		fungivorous	occasional (14)	3,6,17,19,20,21