Invertebrates and Fungi associated with Bridal Creeper, *Asparagus asparagoides* (Asparagaceae), in New Zealand

Helen M. Harman[1], Nick W. Waipara[1], Chris J. Winks[1], Lindsay A. Smith[2], Paul G. Peterson[3] and J. Paula Wilkie[1]

[1]Landcare Research
Private Bag 92170
Auckland 1142, New Zealand

[2]Landcare Research
PO Box 40,
Lincoln 7640, New Zealand

[3]Landcare Research
Private Bag 11052
Palmerston North 4442, New Zealand

Landcare Research Contract Report: LC0708/124

PREPARED FOR:
A National Collective of Regional Councils and the Department of Conservation

DATE: June 2008

Reviewed by:	*Approved for release by:*
Quentin Paynter Scientist Landcare Research	Matt McGlone Science Team Leader Biodiversity and Conservation
Shaun Pennycook Scientist Landcare Research	

Disclaimer
The findings in this report are specific to this project. Landcare Research accepts no responsibility where information in the report is used for any other purpose, and will not be liable for any loss or damage suffered as a result of such other use.

Contents

Summary

Project and Client
A survey of the invertebrate fauna and fungi associated with bridal creeper (smilax), *Asparagus asparagoides* (Asparagaceae), in New Zealand was carried out between November 2005 and January 2007 by Landcare Research for a national collective of regional councils and the Department of Conservation.

Objective
- To survey the invertebrate fauna and fungi associated with bridal creeper, *Asparagus asparagoides*, in New Zealand, and identify the herbivores (and their associated predators and parasitoids) and fungal pathogens present.

Methods
- The invertebrate fauna and fungi associated with bridal creeper were sampled at 37 New Zealand sites (32 sites were sampled for both invertebrates and fungi, with an additional 5 sites sampled for fungi only), ranging from northern Northland to Okains Bay, Banks Peninsula in the South Island.

Results
- No specialist bridal creeper 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).
- Thrips were numerous at some sites and caused distinctive silvery-coloured patches on the foliage.
- Two sap-feeders, *Scolypopa australis* (the passionvine hopper) and *Siphanta acuta*, were the only herbivorous invertebrate species found during the survey to be classed as 'abundant'.
- Generalist predators found on bridal creeper include spiders, ladybirds, lacewings, earwigs, ants, and praying mantids.
- Two organisms were recorded in New Zealand for the first time: the bridal creeper rust fungus, *Puccinia myrsiphilli*, and the portulaca leaf-mining weevil, *Hyperus bertrandi*.
- The bridal creeper rust, *Puccinia myrsiphylli*, was identified at 15 sites in the survey and caused high levels of disease on bridal creeper shoots (including leaves, stems, and fruit).
- A total of 204 fungal isolates were obtained from the 251 bridal creeper tissues plated, which meant the total fungal colonisation of the plated bridal creeper tissue fragments was 81.3%.
- At least 25 different fungal species were identified after being isolated into pure culture.
- *Colletotrichum gloeosporioides* was the most frequently isolated fungal pathogen in the survey. It was primarily associated with a range of stem and leaf necroses, and was occasionally isolated from the tuber tissues suggesting that its infection could have been systemic on some plants.
- A range of weak and secondary opportunistic leaf pathogens were also found to be associated with minor superficial leaf, stem and tuber necroses on bridal creeper.
- No significant primary flower pathogens were isolated from bridal creeper in New Zealand.

Conclusions

- Bridal creeper 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 bridal creeper are well utilised in New Zealand.
- Two sap feeders, *Scolypopa australis* and *Siphanta acuta*, and foliage-feeding lepidopterous larvae, molluscs and thrips appear to be the most damaging invertebrates currently feeding on bridal creeper in New Zealand.
- The bridal creeper rust fungus, *Puccinia myrsiphylli,* which was released in Australia in 2001 as part of a classical biological control programme, is now present in New Zealand.
- Since its arrival the rust has spread autonomously over most of the weed's exotic range in northern New Zealand.
- Bridal creeper is attacked and damaged by the rust over both its active growing seasons (winter–spring, autumn). Damage was often severe causing up to 100% premature defoliation of the plant, prior to both fruit ripening and natural senescence.
- Another primary fungal pathogen of bridal creeper, *Colletotrichum gloeosporioides*, was also found to be widespread. Although *C. gloeosporioides* only caused mild damage to the plant on its own, increased levels of infection and damage by the fungus were observed whenever it was found associated with rust outbreaks on the plant. This observation suggests that a synergistic disease complex formed between the two fungal pathogens.
- The rust is potentially an effective biological control agent for bridal creeper in New Zealand.

Recommendations

- Given the widespread and often severe damage to bridal creeper in New Zealand, caused almost entirely by the rust, we recommend that sourcing additional agents for the classical biological control programme is unwarranted until the rust's impact on bridal creeper populations is assessed.
- Such assessment would require monitoring of the rust's effectiveness in reducing the spread and the biomass of the weed.
- An application to ERMA NZ to 'de-new' the rust under the HSNO Act should be pursued, so that it is no longer regarded legally as a new organism. This would allow land managers to actively manipulate the rust to increase biocontrol efficacy, using methods such as early-season augmentation and introduction to areas where it has not autonomously spread (e.g. South Island). Note ERMA NZ are currently working on such an application.

1. Introduction

A survey of the invertebrate fauna and fungi associated with bridal creeper, *Asparagus asparagoides* (Asparagaceae), in New Zealand was carried out between November 2005 and January 2007 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 the related climbing asparagus, *A. scandens*, in New Zealand (Syrett 1999).

2. Background

Bridal creeper, *Asparagus asparagoides* (L.) Druce, (also known as smilax in New Zealand), is an environmental weed of forest margins, open woodlands, hedges and coastal slopes (Roy et al. 2004), and is invasive in many regions of New Zealand particularly in natural and productive areas of the northern regions of the North Island. It is a scrambling perennial vine that forms both dense canopies that block sunlight from other vegetation and thick mats of tubers and rhizomes that prevent other plants from accessing soil (Esler 2004). Wiry stems with light green leaf-like cladodes arise from tubers and can reach as high as 3 m on supporting vegetation. Small greenish-white flowers appear from winter (July–August), followed by sticky red berries containing black seeds in summer. Above-ground plant parts (leaves and stems) tend to die back in summer and resprout from the below-ground tubers and rhizomes in autumn. The plant is spread readily by either birds, which eat the berries and distribute seed in their droppings, or by movement of root material through human activities such as dumping garden waste.

Bridal creeper is native to southern Africa. It was first noticed as naturalised in New Zealand in the early 1900s (Esler 2004) having been introduced earlier as an ornamental garden plant. It is now common in the northern half of the North Island, particularly Northland, Auckland, Waikato, Bay of Plenty and Gisborne. Although less common further south, it can be found in Wairarapa, Wellington, Nelson, Blenheim, Christchurch and Banks Peninsula. Similarly introduced to Australia as an ornamental in the 1870s, it has now naturalised in all southern states of Australia in a wide range of habitats. In both countries bridal creeper is recognised as a serious environmental weed. In New Zealand it has been declared a serious and unwanted plant pest (Roy et al. 2004) and is on the National Pest Plant Accord list, which lists pest plants determined as unwanted organisms under the Biosecurity Act. In Australia it is listed as one of 20 Weeds of National Significance (Morin & Edwards 2006).

Once introduced to a site, bridal creeper can compete aggressively with other plants by smothering and blocking sunlight as it scrambles over other vegetation and by preventing seedling establishment through its dense mats of rhizomes and tubers. The below-ground storage reserves allow bridal creeper to survive adverse conditions when above-ground foliage dies off and its ability to resprout from root fragments assists in establishment in new locations. It is tolerant of a wide variety of conditions including shade. These characteristics combined with ready dispersal of seeds by birds make it a highly successful invader of both disturbed and undisturbed habitats, including areas that are inaccessible for both detection and control. Bridal creeper infestations can have deleterious environmental impacts by changing the structure, floristic composition and ecology of ecosystems (Morin & Edwards 2006).

Standard control methods for bridal creeper in New Zealand include mechanical methods and herbicides. Manual removal such as grubbing is suitable for small scattered infestations, but care must be taken to remove all root material and to dispose of it properly as it will resprout. Bridal creeper may be controlled by herbicides such as glyphosate while actively growing; however, follow-up monitoring and repeat treatments are required (6-monthly) until seedlings from the soil seed-bank are eliminated. In addition bridal creeper's habit of growing amongst other vegetation means that care must be taken not to harm desirable non-target species especially in areas of high conservation value. Effective treatment of bridal creeper with manual removal and herbicides is both expensive and labour-intensive and not feasible in some places because of the size and inaccessibility of infestations (Morin et al. 2002).

Biological control, if at least partly successful, offers some advantages over current control methods, particularly in areas of high conservation value and that are difficult to reach. Use of host-specific biocontrol agents would reduce chemical herbicide impacts on desirable flora. Biological control also offers continuous action and self-dispersal that current control methods do not offer and can complement other management strategies. A classical biocontrol programme was initiated in Australia in the 1990s. To date three biocontrol agents have been released: a leaf rust, *Puccinia myrsiphylli*; a leaf hopper, *Zygina* sp. (Cicadellidae); and a leaf beetle, *Crioceris* sp. (Chrysomelidae) (Morin & Edwards 2006). The rust and the leaf hopper have established widely and have already demonstrated their capacity to reduce significantly the density of bridal creeper populations. These three agents, and possibly others in the native range, show potential for biological control of bridal creeper in New Zealand.

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

3. Objective

- To survey the invertebrate fauna and fungi associated with bridal creeper, *Asparagus asparagoides*, 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 bridal creeper, *Asparagus asparagoides*, were surveyed at 32 New Zealand sites between November 2005 and January 2007 (Fig. 1; Appendix 1). At each site, 10 collection locations were selected haphazardly. A collecting tray (80 × 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 bridal creeper foliage, in ventilated containers to rear through to adult stage 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. The tuberous root systems of five bridal creeper plants were dug up 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).

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: <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 bridal creeper were surveyed at the same 32 sites from which invertebrates were collected (Fig. 1; Appendix 1) and an additional five sites in the Auckland Region (including the Hauraki Gulf). At each site, plants at each of the 10 invertebrate collection points were inspected closely for signs of pathogen damage, and other bridal creeper plants in the area were examined more superficially for obvious disease symptoms. The five tuberous root systems that were dug up and inspected for invertebrates were also inspected for fungal damage. Diseased leaves, leaf petioles, stems, flowers, flower petioles, berries or roots 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 as well as the pustules of the bridal creeper rust (*Puccinia myrsiphylli*). 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 was consulted to determine which of the identified fungi were likely to be causing the damage with which they were associated. Representative isolates were deposited in the Landcare Research ICMP collection.

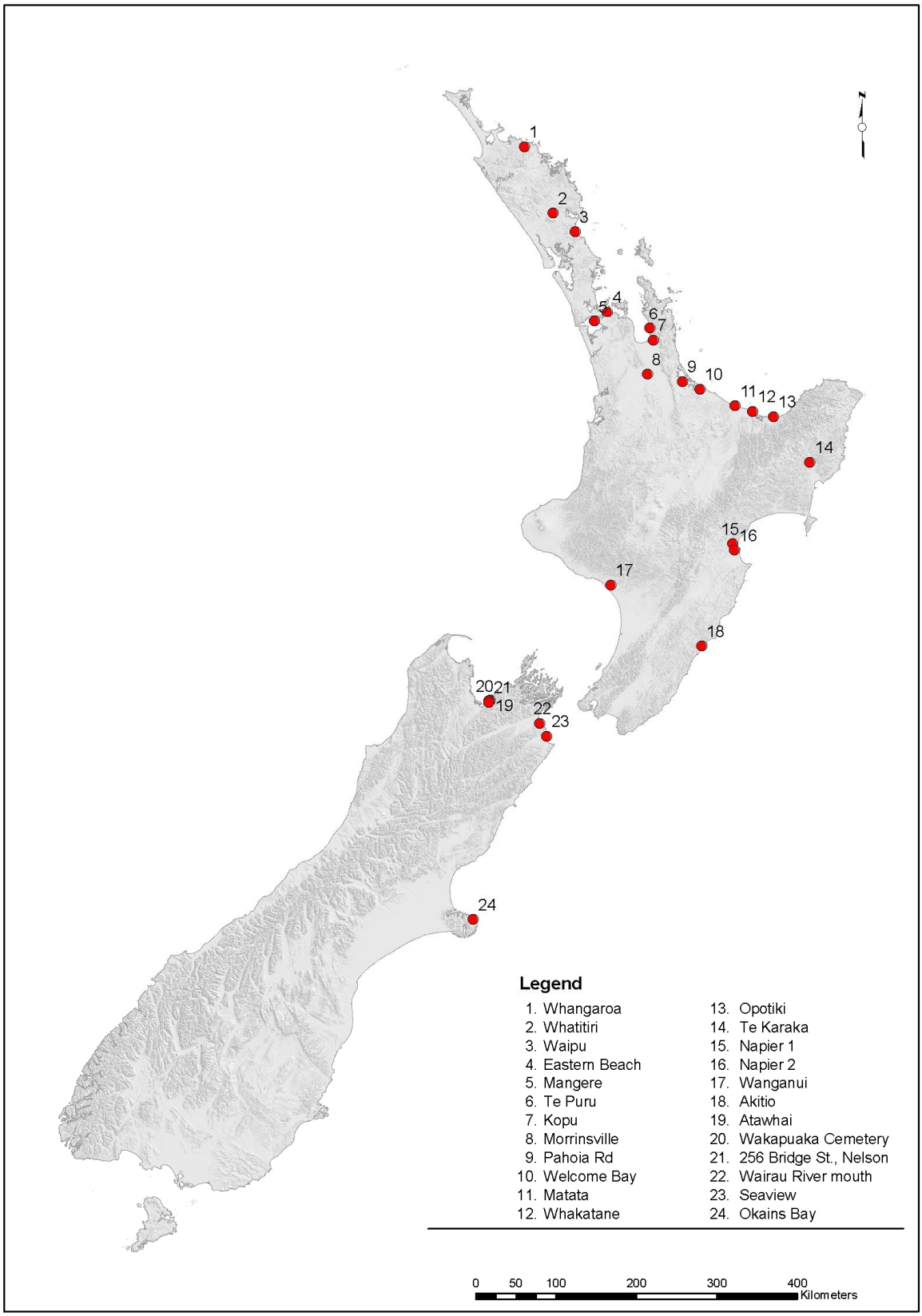

Fig. 1 Locations of bridal creeper (*Asparagus asparagoides*) sites sampled for fungi and invertebrates (2005–2007).

5. Results

5.1 Invertebrates

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

Herbivores

A total of 76 herbivorous invertebrate species was recorded from bridal creeper during this survey. An additional 10 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 9 herbivorous species or taxonomic groupings were classed as 'common', 24 were classed as 'occasional', and 51 were classed as 'rare' (Appendix 1). A list of the abundant, common and occasional herbivorous invertebrates is given below (Table 1).

Foliage feeders: Foliage damage that could be attributed to invertebrate herbivory was minimal. It was rare to find a leaf that was more than 20% consumed, and the overall amount of foliage that appeared to have been consumed or damaged by herbivores was estimated to be less than 1%.

The larvae of a range of moth species, especially tortricid larvae (leafrollers) and to a lesser extent noctuid larvae, occasionally caused obvious damage to leaves. 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 2).

Foliage (especially foliage close to the ground) occasionally showed typical slug or snail damage and slime trails were sometimes visible. If slugs and snails were treated as a combined group (Gastropoda) they would be classed as 'abundant' (Table 1). However, many of the snail species found were very small and only the brown garden snail, *Cantareus aspersus*, is likely to have caused obvious damage.

Banana silvering thrips, *Hercinothrips bicinctus* (Bagnall), were collected from six sites and at some sites they were numerous, producing distinctive silvery-coloured patches on the foliage.

Twenty-nine species, or groups of taxonomically related species, of herbivorous adult beetles were collected during the survey but foliage damage attributed to beetles was minimal. A number of these species might not have feed on bridal creeper but used the foliage as shelter (e.g. the broom seed beetle, *Bruchidius villosus*). One beetle species, collected at Mangere on 10 August 2006, was of particular interest as it is the first record for this species in New Zealand. It is *Hypurus bertrandi*, the portulaca leaf-mining weevil, which is widespread throughout the world on the common weed *Portulaca oleracea*.

Fruit feeders: Little or no damage that could be attributed to invertebrates was observed on the fruit. However, five 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 occasionally 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 bridal creeper flowers (http://www.extento.hawaii.edu/Kbase/////Crop/Type/chelisoc.htm).

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 32 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 bridal creeper during this survey.

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

Parasitoids

Parasitic species that may inhibit introduced biocontrol agents were recorded (Table 2 and Appendix 1).

Predators

Predatory species that may inhibit introduced biocontrol agents were recorded (Table 3 and Appendix 1).

Table 1 Abundant, common, and occasional herbivorous invertebrates collected from bridal creeper at 32 New Zealand sites during 2005–2007. Note: many of these species might not have fed on bridal creeper but used the plant as shelter.

Taxon	Common name	Feeding mode	Frequency	Origin
Phylum Mollusca	**Molluscs**			
Class Gastropoda	**slugs and snails**			
Cantareus aspersus Müller	brown garden snail	foliage feeder	common	introduced
unidentified snails		foliage feeder	common	
unidentified slugs		foliage feeder	occasional	
Phylum Arthropoda				
Class Insecta	**insects**			
Coleoptera	**beetles**			
Chrysomelidae	**leaf beetles**			
Eucolaspis sp.	bronze beetle	foliage feeder	occasional	native
Curculionidae	**weevils**			
Aneuma sp.			occasional	native
Asynonychus cervinus (Boheman)	Fuller's rose weevil	foliage feeder	common	introduced
Gymnetron pascuorum (Gyllenhal)		foliage (larvae specific to seeds of *Plantago lanceolata*)	occasional	introduced
Microcryptorhynchus sp.		foliage feeder	occasional	native
Peristoreus sp.		foliage feeder	occasional	native
Phlyctinus callosus Boheman	garden weevil	foliage feeder	occasional	introduced
Sitona lepidus Gyllenhal	clover root weevil	foliage feeder	occasional	introduced
Elateridae	**click beetles**			
Conoderus exsul (Sharp)	pasture wireworm	adults: foliage/flowers larvae: plant roots and invertebrates	occasional	introduced
Conoderus sp.		adults: foliage/flowers	occasional	
Conoderus posticus (Eschscholtz)		adults: foliage/flowers	occasional	introduced
Dermaptera	**earwigs**			
Forficula auricularia Linnaeus	European earwig	omnivorous: leaves/flowers/fruit and insects	common	introduced
Hemiptera	**bugs**			
Aphididae	**aphids**			
Macrosiphon euphorbiae (Thomas)	potato aphid	sap feeder	occasional	introduced
Cicadellidae	**leafhoppers**			
unidentified Cicadellidae		sap feeder	occasional	
Delphacidae				
Ugyops pelorus Fennah		sap feeder	common	native
Flatidae	**planthoppers**			
Anzora unicolour (Walker)	grey planthopper	sap feeder	occasional	introduced
Siphanta acuta (Walker)	green planthopper	sap feeder	abundant	introduced
Lygaeidae	**seed bugs**			

Taxon	Common name	Feeding mode	Frequency	Origin
Rhypodes sp.		sap/seed feeder	occasional	native
Pentatomidae	**shield bugs**			
Cuspicona simplex Walker	green potato bug	sap feeder	common	introduced
Monteithiella humeralis (Walker)		sap feeder	occasional	introduced
Nezara viridula (Linnaeus)	green vegetable bug	sap feeder	common	introduced
Ricaniidae	**planthoppers**			
Scolypopa australis (Walker)	passionvine hopper	sap feeder	abundant	introduced
Rhyparochromidae				
Metagerra sp.		sap/seed feeder	occasional	native
Targarema stali White		sap/seed feeder	occasional	native
Lepidoptera (collected as larvae and reared to adult for identification)	**moths and butterflies**			
Geometridae	**looper moths**			
unidentified Geometridae		foliage feeder	occasional	
Noctuidae	**armyworms, cutworms**			
unidentified Noctuidae		foliage feeder	occasional	
Psychidae	**bag moths**			
unidentified Psychidae			occasional	
Tortricidae	**leaf rollers**			
Ctenopseustis obliquana (Walker) **or** *C. herana* (Felder and Rogenhofer)		foliage feeder	occasional	native
unidentified Tortricidae		foliage feeder	common	
Orthoptera	**crickets, grasshoppers, weta**			
Grillidae	**crickets**			
Ornebius aperta Otte & Alexander		foliage feeder	occasional	introduced
unidentified Grillidae		foliage feeder	occasional	
Thysanoptera	**thrips**			
Sub-Order Terebrantia				
Thripidae				
Hercinothrips bicinctus (Bagnall)	banana silvering thrips	foliage feeder	common	introduced

Table 2 Parasitic invertebrates collected from invertebrate species associated with bridal creeper at 32 New Zealand sites during 2005–2007.

Taxon	Common name	Frequency	Origin
Diptera	**flies**		
Tachinidae	**bristle flies**		
Trigonospila brevifacies (Hardy)	Australian leafroller tachinid	rare	introduced as a biocontrol agent
Hymenoptera	**bees, wasps, ants**		
Braconidae	**parasitic wasps**		
Glyptapanteles demeter (Wilkinson)		occasional	native
Meteorus pulchricornis Wesmael		rare	introduced
Ichneumonidae			
Xanthocryptus novozealandicus (Dalla Torre)		rare	native

Table 3 Predatory invertebrates collected from bridal creeper at 32 New Zealand sites during 2005–2007.

Taxon	Common name	Frequency	Origin
Phylum Arthropoda			
Class Insecta	**insects**		
Acarina	**mites and ticks**		
Anystidae			
Anystis sp.	**whirlygig mite**	occasional	introduced
Araneida	**spiders**		
unidentified Araneida		abundant	native and introduced
Pseudoscorpiones	**pseudoscorpions**		
unidentified Pseudoscorpiones		occasional	
Class Chilopoda	**centipedes**		
unidentified Chilopoda		rare	
Coleoptera			
Anthicidae			
Anthicus glaber King		occasional	introduced
Sapintus deitzi Werner and Chandler		occasional	introduced
Carabidae	**ground beetles**		
Anomotarus variegatus Moore		rare	introduced
Holcaspis sp.		rare	native
Scopodes sp.		rare	native
unidentified Carabidae		rare	
Coccinellidae	**ladybirds**		
Coccinella undecimpunctata Linnaeus	eleven-spotted ladybird	occasional	introduced as a biocontrol agent
Coelophora inaequalis (Fabricius)	double-cross ladybird	rare	introduced
Cryptolaemus montrouzieri Mulsant	mealybug ladybird	rare	introduced (BCA)
Diomus sp.		rare	introduced
Halmus chalybeus (Boisduval)	steely-blue ladybird	common	introduced (BCA)
Rhyzobius fagus Broun		occasional	introduced
Rhyzobius forestieri (Mulsant)		rare	introduced (BCA)
Rhyzobius sp.		occasional	
Scymnodes lividigaster (Mulsant)	yellow-shouldered ladybird	rare	introduced
Stethorus sp.		occasional	
Melyridae	**flower beetles**		
unidentified Melyridae		occasional	native
Scirtidae	**marsh beetles**		
unidentified Scirtidae		occasional	native
Staphylinidae	**rove beetles**		
Anotylus sp.		rare	introduced
Astenus guttula Fauvel		rare	introduced

Austrolophrum cribriceps (Fauvel)		rare	introduced
Thyreocephalus orthodoxus (Oliff)		rare	introduced
Hemiptera	**bugs**		
Anthocoridae			
unidentified Anthocoridae		occasional	
Nabidae	**damsel bugs**		
Nabis biformis (Bergroth)		rare	native
Nabis sp.		occasional	
Reduviidae	**assassin bugs**		
Empicoris sp.		rare	native
Stenolemus fraterculus Wygodzinsky		rare	introduced
Hymenoptera	**bees, wasps, ants**		
Formicidae	**ants**		
Cardiocondyla minutior Forel		rare	introduced
Iridomyrmex sp.		rare	introduced
Linepithema humile (Mayr)	Argentine ant	occasional	introduced
Monomorium antarcticum (F. Smith)	southern ant	common	native
Monomorium fieldi Forel		rare	native
Ochetellus glaber (Mayr)		occasional	introduced
*Pachycondyla s*p.		rare	native
Paratrechina sp.	garden ant	common	introduced
Pheidole rugosula Forel		occasional	introduced
Prolasius advena (Smith)	small brown bush ant	occasional	introduced
Technomyrmex albipes (Smith)	white-footed house ant	common	introduced
Tetramorium bicarinatum (Nylander)		occasional	introduced
Tetramorium grassii Emery		occasional	introduced
Vespidae	**social wasps**		
Polistes chinensis Fabricius	Asian paper wasp	rare	introduced
Mantodea	**praying mantids**		
Miomantis caffra Saussure	African praying mantis	occasional	introduced
Orthodera novaezealandiae (Colenso)	New Zealand praying mantis	rare	native
Neuroptera	**lacewings**		
Micromus tasmaniae (Walker)	Tasmanian lacewing	common	introduced
Raphidophoridae	**cave weta**		
unidentified Raphidophoridae		occasional	

Fungi

A total of 25 fungal species were identified from a range of severe to mild necroses exhibited on bridal creeper in New Zealand. The bridal creeper rust, *Puccinia myrsiphylli*, was identified directly from symptomatic plant tissues with the remaining fungi identified after being isolated out from tissues into pure culture.

The high level of disease damage often observed on the bridal creeper samples was caused by the bridal creeper rust. The rust was recorded on samples from 15 sites that were geographically spread across most of the weed's North Island distribution (Northland to Wairarapa). The rust was not observed on any of the samples collected from the East Coast (North Island) or South Island.

Initial disease symptoms of the rust on newly infected leaves appeared as small bright yellow wart-like spots on the upper leaf surface and yellow-orange cup-shaped fruiting bodies on the lower surface. As the disease progressed black pustules were also formed on the underside of the leaves, and on the berries and stems. Severely infected shoots then turned tan and brown (resembling plants that have been sprayed with herbicide), leading to the complete dieback and defoliation of plants. Damage at some of the survey sites was often severe causing up to 100% premature defoliation of the plant, prior to both fruit ripening and natural summer senescence.

A total of 204 fungal isolates was obtained from 251 plant tissue pieces plated. Fungal colonisation ([total number of fungal isolates/number of tissue fragments] × 100) averaged across all tissue types (shoot and tuber) was 81.3%. The mean fungal colonisation observed for bridal creeper was in the expected range recorded from previous Landcare Research pathogen weed surveys (Waipara et al. 2005).

At least 36 recognisable taxonomic units (RTUs) were isolated into culture from symptoms of leaf or flower necrosis, with 25 identified to genus and/or species level (Table 4) based on cultural morphology and reproductive (sporulation) characteristics.

A second primary pathogen that was frequently associated with shoot damage on bridal creeper was *Colletotrichum gloeosporioides*, which was observed on samples from 16 of the 37 sites surveyed (Table 4). A total of 58 isolates of this fungus were obtained through plating the symptomatic tissues. Its initial symptom on leaves was the appearance of a characteristic brown circular leaf spot, often with tan-coloured paper-like dry tissue in the centre. It was also found to be associated with a range of other stem and leaf symptoms, such as black stem spots, leaf chlorosis, discolouration, minute finely speckled lesions, leaf tip dieback, and irregular-shaped leaf spots with a water-soaked appearance. The fungus was isolated twice from the tuber tissues suggesting its infection could have been systemic on some plants. Despite the range of shoot necroses caused by *C. gloeosporioides*, overall damage to the plant is minimal from this pathogen alone. However, levels of infection and damage by this fungus were higher when found associated with rust outbreaks on the plant. This observation suggests a synergistic disease complex formed between the two fungal pathogens.

The remainder of isolates from symptomatic shoot and tuber tissues are considered to be secondary, weakly pathogenic or saprophytic fungi with little to no impact on the overall health of bridal creeper.

Table 4 Relative abundance of fungi collected from bridal creeper at 37 sites throughout New Zealand 2005–2007. ([1] = number of sites where each fungi present, [2] = total no. of isolates, L[3] = + recorded from leaf/stem tissue, T[4] = + recorded from tuber-root tissue F[5] = + recorded from fruit-flower tissue)

Species	Sites[1]	Total[2]	L[3]	T[4]	F[5]
Primary pathogens:					
Puccinia myrsiphylli	15+	25	+		+
Colletotrichum gloeosporioides	16	58	+	+	
Secondary pathogens:					
Alternaria alternata	10	21	+		+
Botrytis cinerea	8	23	+	+	+
Fusarium spp. (3 species isolated)	10	24	+		
Pestalotiopsis sp.	2	4	+	+	
Phoma spp. (3 species isolated)	3	6	+		
Phomopsis sp.	10	17	+	+	
unidentified coelomycete spp.	6	11	+	+	
Ulocladium sp.	1	1	+		
Saprophytes/Other:					
Aureobasidium pullulans	4	15	+		+
Acremonium strictum	2	3	+		
Cladosporium cladosporioides	2	2	+		
Epicoccum purpurascens	3	4	+		
Paecilomyces sp.	1	1	+		
Penicillium sp.	2	2	+		
Sterile fungi (*Mycelia sterilia*)	3	3	+		
Unidentified isolates	3	5	+	+	
Yeast/bacteria spp.	3	3	+		
zygomycete sp.	1	1	+		

6. Conclusions

6.1 Invertebrates

Bridal creeper is associated with a wide range of native and introduced invertebrates. However, no specialised bridal-creeper-feeding invertebrates were found during this survey, and overall damage caused by invertebrate herbivory appeared to be minimal. Two sap feeders, *Scolypopa australis* and *Siphanta acuta*, and foliage-feeding lepidopterous larvae, molluscs and thrips appear to be the most damaging invertebrates currently feeding on bridal creeper in New Zealand.

The total amount of bridal creeper foliage that appeared to have been consumed or damaged by herbivorous insects at our survey sites was estimated to be less than 1%. This is at the lower end of the range recorded in similar surveys on other weeds in New Zealand, for example: less than 10% for banana passionfruit (Winks & Fowler 2000); less than 5% for boneseed (Winks et al. 2000); less than 5% for Japanese honeysuckle (Waipara et al. 2005); less than 5% for woolly nightshade (Winks et al. 2001); less than 2% for moth plant (Winks et al. 2004); and less than 2% for tradescantia (Winks et al. 2003).

The combined effects of generalist predators such as spiders, earwigs, ants, praying mantids, and lacewings could inhibit the effectiveness of some potential invertebrate agents for bridal creeper. This has been noted in a few cases for other introduced biocontrol agents such as the gorse spider mite, which is preyed upon by the native coccinellid *Stethorus bifidus* (Peterson et al. 2000), and the broom psyllid, which can be preyed upon by the native mirid *Sejanus albisignatus* (Syrett et al. 2007). Potential lepidopteran biocontrol agents could be affected by some of the parasitoids identified during this survey.

Specialised bridal creeper biocontrol agents are not likely to meet any significant competition with resident herbivores as none of the herbivore niches on bridal creeper are currently well-utilised in New Zealand. Some niches, such as leaf mining, do not appear to be utilised at all. This means that there is scope for the introduction of host-specific invertebrate biocontrol agents that could markedly reduce the vigour of bridal creeper in New Zealand. Potential agents include a leaf hopper, *Zygina* sp. (Cicadellidae), and a leaf beetle, *Crioceris* sp. (Chrysomelidae), which have been released in Australia for biological control of bridal creeper (Morin & Edwards 2006).

6.2 Fungi

The bridal creeper rust fungus, *Puccinia myrsiphylli*, which was released in Australia in 2001 as part of the Australian classical biological control programme, is now present in New Zealand. Since its arrival, the rust has autonomously spread over most of the weed's exotic range in northern New Zealand. Bridal creeper was attacked and damaged by the rust over both its active growing seasons (winter–spring, autumn). Damage was often severe causing up to 100% premature defoliation of the plant, prior to both fruit ripening and natural senescence. The rust is potentially an effective biocontrol agent for bridal creeper in New Zealand. Observations and studies in Australia indicate that the rust is very damaging to bridal creeper with the cumulative effect over several seasons on above- and below-ground biomass and fruit set likely to reduce plant vigour and density (Morin et al. 2002; Morin & Edwards 2006).

The other primary fungal pathogen of bridal creeper detected in this survey, *Colletotrichum gloeosporioides*, was also found to be widespread. Although *C. gloeosporiodes* caused only mild damage to the plant on its own, increased levels of infection and damage by the fungus were observed when it was found associated with rust outbreaks on the plant. This observation suggests that a synergistic disease complex was formed between the two fungal pathogens.

7. Recommendations

- Given the widespread and often severe damage to bridal creeper in New Zealand, caused almost entirely by the rust, we recommend that sourcing additional agents for a classical biological control programme is unwarranted until the impact of the rust on bridal creeper populations has been assessed.
- Such assessment would require monitoring of the rust's effectiveness in reducing the spread and the biomass of the weed.
- An application to ERMA NZ to 'de-new' the rust under the HSNO Act should be pursued, so that it is no longer regarded legally as a new organism. This would allow land managers to actively manipulate the rust to increase biocontrol efficacy, using methods such as early-season augmentation and introduction to areas where it has not autonomously spread (e.g. South Island). Note ERMA NZ are currently working on such an application.

8. Acknowledgements

We thank Lynley Hayes for project liaison with the funding collective. We thank the following people for helping to identify invertebrate material: J.A. Berry (Hymenoptera); R. Henderson (mites, scale insects); R. Hoare (Lepidoptera); M-C. Larivière (Hemiptera); R. Leschen (Coleoptera); S. Thorpe (Coleoptera and Hemiptera, and checking the spelling of the invertebrate species list); and Z-Q. Zhang (mites). Asher Jones, Jo Rees, Jenni Stanley and Richard Toft are thanked for their technical assistance. We also thank regional council and Department of Conservation staff for their help in locating sites. Quentin Paynter, Shaun Pennycook and Lynley Hayes provided helpful comments on the draft report. Thanks to Hamish Heke for the illustration and to Christine Bezar for editorial assistance.

9. References

Esler AE 2004. Wild plants in Auckland. Auckland, Auckland University Press. 218 p.

Larivière M-C 1995. Cydnia, Acanthosomatidae, and Pentatomidae (Insect: Heteroptera). Fauna of New Zealand 35. Lincoln, Manaaki Whenua Press. 112 p.

Morin L, Edwards PB 2006. Selection of biological control agents for bridal creeper: a retrospective review. Australian Journal of Entomology 45: 287–291.

Morin L, Willis AJ, Armstrong J, Kriticos D 2002. Spread, epidemic development and impact of the bridal creeper rust in Australia: summary of results. In: Spafford Jacob H, Dodd J, Moore JH eds Proceedings of the 13th Australian Weeds Conference. Perth, Australia, Plant Protection Society of WA Inc. Pp. 385–388.

Mound LA, Walker AK 1982. Terebrantia (Insecta: Thysanoptera). Fauna of New Zealand 1. Wellington, DSIR, Science Information Division. 113 p.

Peterson PG, McGregor PG, Springett BP 2000. Density dependent prey-feeding time of *Stethorus bifidus* (Coleoptera: Coccinellidae) on *Tetranychus lintearius* (Acari: Tetranychidae). New Zealand Journal of Zoology 27: 41–44.

Roy B, Popay I, Champion P, James T, Rahman A 2004. An illustrated guide to common weeds in New Zealand. 2nd edn. Lincoln, New Zealand Plant Protection Society.

Syrett P 1999. Prospects for biological control of climbing asparagus, *Asparagus scandens* Thunberg (Asparagaceae). Landcare Research Contract Report LC9899/104 (unpublished). 15 p.

Syrett P, Fowler SV, Harman HM, Hayes LM, Memmott J, Sheat JJ 2007. Establishment of *Arytainilla spartiophila* Förster (Hemiptera: Psyllidae), a new biological control agent for broom, *Cytisus scoparius*, in New Zealand. New Zealand Entomologist 30: 53–62.

Waipara NW, Winks CJ, Smith LA, Wilkie JP 2005. Invertebrates and fungi associated with Japanese honeysuckle, *Lonicera japonica* (Caprifoliaceae), in New Zealand. Landcare Research Contract Report LC0506/026 (unpublished). 44 p.

Winks CJ, Fowler SV 2000. Banana passionfruit, *Passiflora mollissima* and *Passiflora mixta* (Passifloraceae), in New Zealand: Surveys of their weed status and invertebrate fauna. Landcare Research Contract Report LC9900/144 (unpublished). 29 p.

Winks CJ, Fowler SV, Smith LA 2000. The invertebrate fauna of bone-seed, *Chrysanthemoides monilifera* spp. *monilifera*, in New Zealand. Landcare Research Contract Report LC9900/137 (unpublished). 24 p.

Winks CJ, Fröhlich J, fowler SV, Gianotti AF 2001. Invertebrates and fungi associated with woolly nightshade (*Solanum mauritianum*, Solanaceae) in New Zealand. Landcare Research Contract Report LC0001/157 (unpublished). 42 p.

Winks CJ, Waipara NW, Gianotti AF, Fowler SV 2003. Invertebrates and fungi associated with *Tradescantia fluminensis* (Commelinaceae) in New Zealand. Landcare Research Contract Report LC0203/153 (unpublished). 40 p.

Winks CJ, Waipara NW, Gianotti AF 2004. Invertebrates and fungi associated with moth plant, *Araujia sericifera*, in New Zealand. Landcare Research Contract Report LC0405/009 (unpublished). 29 p.

Appendix 1 Invertebrates associated with bridal creeper, *Asparagus asparagoides*, at 32 New Zealand sites (2005–2007)

Key 1: Definitions of frequency categories

rare: >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

Key 2: Collection sites (refer to Fig. 1 for locations) and date sampled (day.month.year)

1	Whangaroa	(9.12.05)	14	Te Karaka	(22.08.06)
2	Whatitiri	(8.12.05)	15	Napier 1	(23.08.06)
3	Waipu	(7.12.05)	16	Napier 2	(23.08.06)
4	Eastern Beach	(10.08.06)	17	Wanganui	(27.11.05)
5-1	Mangere 1	(16.11.05)	18-1	Akitio 1	(12.12.05)
5-2	Mangere 2	(24.04.06)	18-2	Akitio 2	(08.06.06)
5-3	Mangere 3	(10.08.06)	19	Atiwhai	(21.12.05)
6	Te Puru	(21.08.06)	20-1	Wakapuaka Cmtry 1	(21.12.05)
7	Kopu	(20.11.05)	20-2	Wakapuaka Cmtry 2	(13.09.06)
8	Morrinsville	(24.08.06)	21	Bridge Street	(13.09.06)
9	Pahoia Rd	(23.11.05)	22-1	Wairau River Mouth 1	(23.02.06)
10	Welcome Bay	(04.04.06)	22-2	Wairau River Mouth 2	(13.09.06)
11-1	Matata 1	(21.11.05)	23	Seaview	(23.02.06)
11-2	Matata 2	(04.04.06)	24-1`	Okains Bay 1	(10.04.06)
12	Whakatane	(04.04.06)	24-2	Okains Bay 2	(27.09.06)
13	Opotiki	(22.08.06)	24-3	Okains Bay 3	(16.01.07)

Taxon	Common name	Feeding mode	Frequency and (total no.)	Collection sites
Phylum Mollusca	**molluscs**			
Class Gastropoda	**slugs and snails**			
Cantareus aspersus Müller	brown garden snail	herbivorous	common (86)	4, 5-3, 9, 10, 14, 15, 18-2, 21, 22-2
unidentified snails		herbivorous	common (179)	1, 3, 4, 5-1, 5-2, 5-3, 6, 10, 11-1, 11-2, 12, 18-1
unidentified slugs		herbivorous	occasional (6)	3, 18-1
Phylum Arthropoda				
Class Crustacea				
Amphipoda				
unidentified Amphipoda		saprophytic	rare (2)	6
Isopoda	**slaters**			
unidentified Isopoda		saprophytic	common (105)	2, 5-2, 5-3, 6, 8, 9, 10, 11-2, 12, 18-1
Class Arachnida				
Acarina	**mites and ticks**			
Anystidae				

Taxon	Common name	Feeding mode	Frequency and (total no.)	Collection sites
Anystis sp.	**whirlygig mite**	predatory	occasional (22)	9, 10, 11-1, 12, 20-2, 21, 22-2
Oribatida	**oribatid mites**			
unidentified Oribatida		fungivorous	occasional (45)	3, 10, 18-1, 20-2
Araneida	**spiders**			
unidentified Araneida		predatory	abundant (578)	1, 2, 3, 4, 5-1, 5-2, 5-3, 6, 7, 8, 9, 10, 11-1, 11-2, 12, 13, 14, 15, 16, 17, 18-1, 18-2, 19, 20-1, 20-2, 21, 22-2, 24-1, 24-3
Pseudoscorpiones	**pseudoscorpions**			
unidentified Pseudoscorpiones		predatory	occasional (9)	3, 5-1, 18-1, 24-3
Class Diplopoda	**millipedes**			
unidentified Diplopoda		saprophytic	rare (3)	3, 18-1
Class Chilopoda	**centipedes**			
unidentified Chilopoda		predatory	rare (1)	18-1
Class Collembola	**springtails**			
unidentified Collembola		saprophytic	common (99)	4, 18-1, 18-2, 20-2, 21, 22-2
Class Insecta	**insects**			
Archeognatha	**bristle tails**			
unidentified Archeognatha		algae, lichens and decaying matter	rare (2)	6, 13
Blattodea	**cockroaches**			
Celatoblatta sp.		saprophytic	common (74)	1, 2, 4, 6, 8, 9, 11-1, 13, 14, 15, 17
Celeriblattina minor Johns		saprophytic	occasional (9)	18-1
Celeriblattina sp.		saprophytic	occasional (29)	10, 11-1, 11-2, 12
Parellipsidion latipennis (Brunner von Wattenwyl)		saprophytic	rare (4)	7
Parellipsidion sp.		saprophytic	common (62)	1, 2, 6, 10, 11-1, 18-1
unidentified Blattodea		saprophytic	occasional (7)	8, 14, 16, 20-2
Coleoptera	**Beetles**			
Aderidae	**puppet beetles**			
Xylophilus sp.			rare (3)	17
Anobiidae	**borer beetles**			
Sphinditeles sp.		herbivorous	rare (4)	24-3

Taxon	Common name	Feeding mode	Frequency and (total no.)	Collection sites
unidentified Anobiidae		herbivorous	rare (1)	3
Anthicidae	**ant beetles**			
Anthicus glaber King		omnivorous	occasional (17)	4
Sapintus deitzi Werner and Chandler		omnivorous	occasional (11)	3, 5-3
Anthribidae	**fungus weevils**			
Dysnocryptus inflatus (Sharp)		fungivorous	rare (4)	5-3
Dysnocryptus pallidus Broun		fungivorous	occasional (6)	18-1
Dysnocryptus sp.		fungivorous	rare (1)	5-1
Euciodes suturalis Pascoe		fungivorous	rare (4)	11-1, 17, 18-1
Garyus altus (Sharp)		fungivorous	rare (1)	2
Lawsonia viriabilis Sharp		fungivorous	rare (1)	4
Phymatus sp.		fungivorous	rare (1)	18-1
Pleosporius bullatus (Sharp)		fungivorous	rare (1)	2
Sharpius brouni (Sharp)		fungivorous	occasional (12)	2, 5-2, 5-3, 8, 9, 10, 12, 15
Carabidae	**ground beetles**			
Anomotarus variegatus Moore		predatory	rare (1)	11-2
Holcaspis sp.		predatory	rare (1)	18-1
Scopodes sp.		predatory	rare (2)	15
unidentified Carabidae		predatory	rare (1)	18-1
Cerambycidae	**longhorn beetles**			
Psilocnaeia sp.		herbivorous	occasional (12)	4, 17, 18-1, 24-3
Ptinosoma sp.		herbivorous	rare (1)	6
Xylotoles griseus (Harris)		herbivorous	rare (3)	12
Xylotoles sp.		herbivorous	occasional (10)	2, 3, 4, 5-1, 10, 11-2, 18-1
Zorion sp.	flower longhorn	herbivorous	rare (1)	18-1
Chrysomelidae	**leaf beetles**			
Bruchidius villosus (Fabricius)	broom seed beetle	herbivorous (feeds on broom)	rare (1)	20-2
Eucolaspis sp.	bronze beetle	herbivorous	occasional (19)	2, 3, 17, 18-1
Peniticus sp.		herbivorous	rare (2)	14
Ciidae				
unidentified Ciidae		fungivorous	rare	18-1

Taxon	Common name	Feeding mode	Frequency and (total no.)	Collection sites
			(1)	
Coccinellidae	**ladybirds**			
Coccinella undecimpunctata Linnaeus	eleven-spotted ladybird	predatory	occasional (12)	1, 5-2, 5-3, 8, 11-2, 13, 14
Coelophora inaequalis (Fabricius)	double-cross ladybird	predatory	rare (1)	12
Cryptolaemus montrouzieri Mulsant	mealybug ladybird	predatory	rare (1)	3
Diomus sp.		predatory	rare (1)	16
Halmus chalybeus (Boisduval)	steely-blue ladybird	predatory	common (150)	4, 5-3, 6, 8, 9, 14, 15, 16, 20-2, 21
Rhyzobius fagus (Broun)		predatory	occasional (20)	1, 5-1, 5-3, 11-2, 17, 20-1
Rhyzobius forestieri (Mulsant)		predatory	rare (2)	4, 16
Rhyzobius sp.		predatory	occasional (7)	11-1
Scymnodes lividigaster (Mulsant)	yellow-shouldered ladybird	predatory	rare (3)	4, 5-3, 12
Stethorus sp.		predatory	occasional (11)	4, 14, 15, 18-1, 20-2
Corylophidae	**hooded beetles**			
Arthrolips oblonga (Broun)		fungivorous	rare (1)	15
Sericoderus sp.		fungivorous	occasional (20)	5-2, 14, 15, 16, 18-1, 18-2, 20-1, 24-3
Cryptophagidae	**cryptic beetles**			
Micrambina sp.		pollen/ fungus feeder	occasional (21)	4, 18-1, 20-2
Paratomaria sp.		pollen/ fungus feeder	common (110)	2, 3, 5-3, 13, 14, 15, 17, 18-1, 18-2, 20-2, 21, 24-3
Curculionidae	**weevils**			
Aneuma sp.		herbivorous	occasional (11)	14, 18-1, 20-2
Asynonychus cervinus (Boheman)	Fuller's rose weevil	herbivorous	common (37)	4, 5-2, 5-3, 10, 14, 15, 22-1
Gymnetron pascuorum (Gyllenhal)		herbivorous	occasional (6)	5-2, 5-3
Hypurus bertrandi (Perris)	portulaca weevil	herbivorous	rare (1)	5-3
Irenimus sp.		herbivorous	rare (1)	12
Listroderes sp.		herbivorous	rare (1)	10
Microcryptorhynchus sp.		herbivorous	occasional (6)	3, 5-1, 8, 11-2
Microtribus huttoni Wollaston		herbivorous	rare (1)	4
Mitrastethus baridioides (Redtenbacher)	long-nosed kauri weevil	herbivorous (feeds on kauri)	rare (1)	9
Neomycta rubida Broun		herbivorous	rare (2)	12

Taxon	Common name	Feeding mode	Frequency and (total no.)	Collection sites
Novitas sp.		herbivorous	rare (1)	18-1
Peristoreus sp.		herbivorous	occasional (12)	6, 18-1, 24-3
Phloeophagosoma sp.		herbivorous	rare (1)	2
Phlyctinus callosus Boheman	garden weevil	herbivorous	occasional (5)	2, 10
Praolepra sp.		herbivorous	rare (1)	18-1
Rhadinosomus acuminatus (Fabricius)		herbivorous on *Haloragis erecta*	rare (1)	12
Sericotrogus subaenescens Wollaston		larvae and adults in dead wood	common (160)	1, 2, 3, 4, 5-1, 5-2, 5-3, 7, 9, 10, 11-1, 11-2, 12, 13, 14
Sitona discoideus Gyllenhal	sitona weevil	herbivorous	rare (1)	12
Sitona lepidus Gyllenhal	clover root weevil	herbivorous	occasional (8)	1, 2, 3
Dermestidae	**hide beetles**			
Reesa vespulae (Milliron)		pollen feeder	rare (1)	18-1
Trogoderma sp.		pollen feeder	rare (2)	18-1, 22-2
Elateridae	**click beetles**			
Conoderus exsul (Sharp)	pasture wireworm	herbivorous	occasional (7)	9, 11-2, 12
Conoderus sp.		herbivorous	occasional (5)	10
Conoderus posticus (Eschscholtz)		herbivorous	occasional (15)	5-2, 5-3, 10
Panspoeus guttatus Sharp		herbivorous	rare (1)	17
unidentified Elateridae			rare (1)	18-1
Erotylidae	**handsome fungus beetles**			
Loberus nitens (Sharp)		saprophytic	abundant (251)	3, 4, 5-1, 5-2, 5-3, 10, 11-1, 11-2, 13, 17
Latridiidae	**mildew beetles**			
Aridius bifasciatus (Reitter)		fungivorous	common (81)	3, 4, 8, 14, 15, 16, 17, 18-1, 18-2, 22-2
Aridius nodifer (Westwood)		fungivorous	occasional (6)	15
Melanophthalma sp.		fungivorous	common (134)	2, 5-1, 7, 9, 10, 15, 17, 18-1, 18-2, 24-1, 24-3
unidentified Latridiidae		fungivorous	common (55)	4, 5-3, 8, 14, 16, 20-2, 22-2
Melyridae	**flower beetles**			
unidentified Melyridae		predatory	occasional (35)	24-3
Mordellidae	**pintail beetles**			

Taxon	Common name	Feeding mode	Frequency and (total no.)	Collection sites
Mordella jucunda (Broun)		herbivorous	rare (1)	18-1
Mycetophagidae	**fungus beetles**			
Litargus vestitus (Sharp)		fungivorous	common (179)	4, 5-2, 5-3, 9, 10, 14, 15, 16
Salpingidae	**bark mould beetles**			
unidentified Salpingidae		fungivorous	rare (1)	18-1
Scarabaeidae	**scarab beetles**			
Costelytra zealandica (White)	New Zealand grass grub	herbivorous	rare (2)	4, 18-1
Scirtidae	**marsh beetles**			
unidentified Scirtidae		predatory	occasional (13)	5-1, 11-1, 11-2, 13, 15, 16
Silvanidae	**flat beetles**			
Ahasverus advena (Waltl)		fungivorous	rare (1)	10
Staphylinidae	**rove beetles**			
Anotylus sp.		predatory	rare (1)	4
Astenus guttula Fauvel		predatory	rare (2)	10
Austrolophrum cribriceps (Fauvel)		predatory	rare (1)	9
Thyreocephalus orthodoxus (Oliff)		predatory	rare (1)	2
Tenebrionidae	**darkling beetles**			
unidentified Tenebrionidae			rare (2)	11-2, 18-1
Trogossitidae	**cadelle beetles**			
Australiodes vestitus (Broun)			rare (7)	15
Rentonidium costiventris Crowson			rare (2)	15
Zopheridae	**false darkling beetles**			
Pristoderus asper (Sharp)		fungivorous	rare (1)	5-3
Dermaptera	**earwigs**			
Forficula auricularia Linnaeus	European earwig	omnivorous	common (25)	5-1, 5-2, 5-3, 9, 10, 12, 15, 20-2
Diptera	**flies**			
Tachinidae	**bristle flies**			
Trigonospila brevifacies (Hardy)	Australian leafroller tachinid	parasitoid	rare (1)	10
Hemiptera	**bugs**			
Anthocoridae				
unidentified Anthocoridae		predatory	occasional (22)	2, 4, 7, 9, 10, 16, 17, 18-1, 18-2, 20-2, 21

Taxon	Common name	Feeding mode	Frequency and (total no.)	Collection sites
Aphididae	**aphids**			
Aphis gossypii Glover	melon aphid	sap feeder	rare (2)	15, 22-1
Macrosiphon euphorbiae (Thomas)	potato aphid	sap feeder	occasional (22)	1, 9, 18-1, 21
Toxoptera aurantii (Boyer de Fonscolombe)	black citrus aphid	sap feeder	rare (2)	2, 11-1
Aphrophoridae	**spittle bugs**			
Carystoterpa fingens (Walker)	variegated spittle bug	sap feeder	rare (1)	1
Philaenus spumarius (Linnaeus)	meadow spittle bug	sap feeder	rare (2)	12, 24-3
Berytidae				
Bezu wakefieldi (White)		sap feeder	rare (3)	18-1
Cicadellidae	**leafhoppers**			
unidentified Cicadellidae		sap feeder	occasional (7)	5-3, 6, 16
Cixiidae				
Aka sp.		sap feeder	rare (2)	24-1
Oliarus oppositus (Walker)		sap feeder	rare (2)	9, 18-1
Coccidae	**soft scales**			
Saissetia coffeae (Walker)	hemispherical scale	sap feeder	rare (1)	10
Delphacidae				
Ugyops pelorus Fennah		sap feeder	common (163)	1, 6, 12, 13, 18-1, 18-2
Ugyops sp.		sap feeder	rare (1)	24-3
Flatidae	**planthoppers**			
Anzora unicolour (Walker)	grey planthopper	sap feeder	occasional (7)	11-2, 18-1, 20-1
Siphanta acuta (Walker)	green planthopper	sap feeder	abundant (482)	1, 2, 3, 4, 5-1, 5-2, 5-3, 6, 7, 8, 9, 10, 11-1, 11-2, 12, 13, 14, 15, 16, 17, 18-1, 18-2, 20-2, 21, 22-2
Heterogastridae				
Heterogaster urticae (Fabricius)		sap/seed feeder	rare (2)	22-2
Lygaeidae	**seed bugs**			
Rhypodes sp.		sap/seed feeder	occasional (8)	2, 18-1
Miridae	**mirid bugs**			
Chinamiris sp.		sap feeder	rare (2)	24-3
Closterotomus	potato mirid	sap feeder	rare	18-1

Taxon	Common name	Feeding mode	Frequency and (total no.)	Collection sites
norwegicus (Gmelin)			(1)	
Stenotus binotatus (Fabricius)	slender crop mirid	sap feeder	rare (2)	2, 18-1
unidentified Miridae			rare (3)	12, 14, 24-3
Nabidae	**damsel bugs**			
Nabis biformis (Bergroth)		predatory	rare (1)	17
Nabis sp.		predatory	occasional (40)	7, 9, 11-1, 17
Pentatomidae	**shield bugs**			
Cuspicona simplex Walker	green potato bug	sap feeder	common (25)	5-2, 5-3, 7, 8, 13, 14, 15, 16, 20-2
Dictyotus caenosus (Westwood)	brown shield bug	sap feeder	rare (4)	8, 16, 17
Glaucias amyoti (Dallas)	New Zealand vegetable bug	sap feeder	rare (1)	11-1
Monteithiella humeralis (Walker)		sap feeder	occasional (10)	6, 12, 14
Nezara viridula (Linnaeus)	green vegetable bug	sap feeder	common (71)	1, 4, 5-3, 6, 7, 8, 10, 11-1, 11-2, 12, 13, 14, 16, 21
Psyllidae				
unidentified Psyllidae		sap feeder	rare (2)	20-2
Reduviidae	**assassin bugs**			
Empicoris sp.		predatory	rare (1)	18-1
Stenolemus fraterculus Wygodzinsky		predatory	rare (1)	1
Ricaniidae	**planthoppers**			
Scolypopa australis (Walker)	passionvine hopper	sap feeder	abundant (531)	1, 2, 5-2, 9, 10, 11-2, 12, 17, 18-1, 19, 20-1
Rhyparochromidae				
Dieuches notatus (Dallas)		sap/seed feeder	rare (3)	10
Horridipamera robusta Malipatil		sap/seed feeder	rare (2)	5-3, 12
Metagerra obscura White		sap/seed feeder	rare (1)	18-1
Metagerra sp.		sap/seed feeder	occasional (10)	18-1, 18-2, 20-2, 24-3
Remaudiereana inornata (Walker)		sap/seed feeder	rare (1)	10
Targarema electra White		sap/seed feeder	rare (2)	12, 18-1
Targarema stali White		sap/seed feeder	occasional (7)	2, 7, 18-1
Targarema sp.		sap/seed feeder	rare (1)	18-1
Hymenoptera	**bees, wasps, ants**			
Braconidae	**parasitic wasps**			
Glyptapanteles demeter		parasitoid	occasional	5-1

Taxon	Common name	Feeding mode	Frequency and (total no.)	Collection sites
(Wilkinson)			(12)	
Meteorus pulchricornis Wesmael		parasitoid	rare (4)	5-1, 10, 16
Formicidae	**ants**			
Cardiocondyla minutior Forel		omnivorous	rare (1)	10
Iridomyrmex sp.		omnivorous	rare (2)	14
Linepithema humile (Mayr)	Argentine ant	omnivorous	occasional (18)	4
Monomorium antarcticum (F. Smith)	southern ant	omnivorous	common (27)	3, 6, 7, 11-2, 14, 18-2
Monomorium fieldi Forel		omnivorous	rare (1)	4
Ochetellus glaber (Mayr)		omnivorous	occasional (81)	4, 5-3, 14, 16
*Pachycondyla s*p.		omnivorous	rare (1)	18-1
Paratrechina sp.	garden ant	omnivorous	common (75)	1, 3, 4, 6, 7, 10, 12
Pheidole rugosula Forel		omnivorous	occasional (7)	4
Prolasius advena (Smith)	small brown bush ant	omnivorous	occasional (62)	13, 18-1
Technomyrmex albipes (Smith)	white-footed house ant	omnivorous	common (149)	1, 2, 4, 5-1, 5-2, 5-3, 6, 8, 9, 10, 11-1, 11-2, 14, 15, 20-2, 21
Tetramorium bicarinatum (Nylander)		omnivorous	occasional (26)	11-2, 12
Tetramorium grassii Emery		omnivorous	occasional (6)	1, 5-2, 5-3, 10
Ichneumonidae				
Xanthocryptus novozealandicus (Dalla Torre)		parasitoid	rare (1)	18-1
Vespidae	**social wasps**			
Polistes chinensis Fabricius	Asian paper wasp	omnivorous	rare (3)	11-2, 13
Lepidoptera (collected as larvae and reared to adult for identification)	**moths and butterflies**			
Geometridae	**looper moths**			
Xyridacma ustaria (Walker)		herbivorous	rare (1)	5-1
unidentified Geometridae		herbivorous	occasional (5)	5-2, 11-1, 18-1, 24-3
Noctuidae	**armyworms, cutworms**			
Chrysodeixis eriosoma (Doubleday)	green looper or silver Y moth	herbivorous	rare (2)	5-1
Rhapsa scotosialis Walker	slender owlet	herbivorous	rare (1)	2
unidentified Noctuidae		herbivorous	occasional (16)	5-2, 5-3, 6, 10, 11-2, 12, 15, 18-1, 18-2, 24-3

Taxon	Common name	Feeding mode	Frequency and (total no.)	Collection sites
Psychidae	**bag moths**			
Lepidoscia lainodes Meyrick	little log cabin bag moth	herbivorous algal feeder	rare (1)	5-2
unidentified Psychidae		herbivorous	occasional (5)	1
Tortricidae	**leaf rollers**			
Cnephasia jactatana Walker	black-lyre moth	herbivorous	rare (4)	5-1, 5-2, 18-1
Ctenopseustis obliquana (Walker) **or** *C. herana* (Felder and Rogenhofer)		herbivorous	occasional (16)	2, 3, 5-1, 5-2, 9, 10
Epiphyas postvittana (Walker)	light-brown apple moth	herbivorous	rare (3)	2, 3, 18-2
unidentified Tortricidae		herbivorous	common (35)	2, 3, 5-1, 5-2, 5-3, 6, 7, 9, 10, 11-1, 13, 15, 18-1, 24-3
Mantodea	**praying mantids**			
Miomantis caffra Saussure	African praying mantis	predatory	occasional (7)	1, 9
Orthodera novaezealandiae (Colenso)	New Zealand praying mantis	predatory	rare (2)	3, 21
Neuroptera	**lacewings**			
Micromus tasmaniae (Walker)	Tasmanian lacewing	predatory	common (77)	2, 3, 4, 5-1, 5-2, 5-3, 6, 7, 8, 9, 10, 14, 16, 17, 18-1, 18-2, 20-2, 21, 22-2, 24-3
Orthoptera	**crickets, grasshoppers, weta**			
Grillidae	**crickets**			
Metioche maoricum (Walker)	mute cricket	herbivorous	rare (1)	24-1
Ornebius aperta Otte & Alexander		herbivorous	occasional (6)	1
unidentified Grillidae		herbivorous	occasional (11)	4, 14, 16, 24-1, 24-3
Raphidophoridae	**cave weta**			
unidentified Raphidophoridae		omnivorous	occasional (14)	1, 5-2, 7, 11-1, 13, 18-2, 22-2
Tettigoniidae	**long-horned grasshoppers**			
Caedicia simplex (Walker)	katydid	herbivorous	rare (2)	8, 11-1
Conocephalus sp.	field grasshopper	herbivorous	rare (3)	3, 24-3
Phasmatodea	**stick insects**			
Clitarchus hookeri (White)	smooth stick insect	herbivorous	rare (3)	9, 17
Psocoptera	**book lice**			
unidentified Psocoptera		saprophytic and fungivorous	common (88)	2, 3, 4, 5-1, 5-2, 6, 10, 15, 17, 18-1, 18-2, 20-2, 21,

Taxon	Common name	Feeding mode	Frequency and (total no.)	Collection sites
				22-2, 24-3
Thysanoptera	**thrips**			
Sub-Order Terebrantia				
Thripidae				
Hercinothrips bicinctus (Bagnall)	banana silvering thrips	herbivorous	common (42)	4, 5-1, 5-2, 5-3, 18-1, 20-2
Thrips obscuratus (Crawford)	New Zealand flower thrips	herbivorous	occasional (5)	5-3, 20-2, 21
Sub-Order Tubulifera				
unidentified Tubulifera		fungivorous	occasional (12)	5-3, 9, 18-1, 21