DISTRIBUTION AND NEW HOST RECORDS FOR *COSMOSPORA AURANTICOLA* AND *COSMOSPORA* *FLAMMEA*: ENTOMOPATHOGENS OF DIASPIDIDAE IN NEW ZEALAND

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ABSTRACT

Adventive armoured scale insects (Diaspididae) are of particular concern in New Zealand horticulture due to their polyphagous nature, the damage they can cause, and their implications in biosecurity. Two important species of fungal entomopathogens recorded on armoured scale insects in New Zealand are *Cosmospora aurantiicola* (*Fusarium larvarum*) and *C. flammea* (*F. coccophilum*). Both have previously been recorded in New Zealand from unidentified Coccoidea; *C. aurantiicola* has also been recorded on *Hemiberlesia lataniae* and *H. rapax*. During 2002–2003, five forays were carried out to provide further information on the host range of the species and to collect strains of the entomopathogens that may have potential as biocontrol agents for armoured scale insects. *Aspidiotus nerii*, *Hemiberlesia* sp., *Leucaspis brittini*, *Leucaspis* spp., *Pinnaspis dysoxyl* and *Eriococcus cavelli* (Eriococcidae) were recorded as new host species for *C. flammea*. *Hemiberlesia lataniae* is reconfirmed as a host for both species.

Keywords: *Cosmospora aurantiicola*, *Cosmospora flammea*, entomopathogen, Diaspididae, New Zealand.

INTRODUCTION

Armoured scale insects (Diaspididae) are a family of highly specialized insects, many of which, e.g. Californian red scale *Aonidiella aurantii*, greedy scale *Hemiberlesia rapax* and white peach scale *Pseudaulacaspis pentagona*, are important agricultural pests. Worldwide they number over 2000 species (Gill 1997).

Armoured scale insects are sapsuckers and may cause loss of vigour, deformation of plant parts, yellowish spots on leaves, loss of leaves and even death of the host plant (Gill 1997; Beardsley & Gonzalez 1975). Being sessile, colonial and often rather cryptic, many species have invaded new countries with infested plant material and can be a quarantine problem for both importing and exporting countries. This has made them prime targets for biological control programmes using both insect parasitoids and fungal entomopathogens. Unlike other biological control pathogens such as *Bacillus thuringiensis* (which must be ingested to be effective) fungal entomopathogens can infect their host by penetrating directly through the insect cuticle (Ferron 1978).

Two species of fungal entomopathogens are commonly recorded from armoured scale insects in New Zealand. They are *Cosmospora* (*Nectria*) *auranticola* (anamorph *Fusarium larvarum*) and *Cosmospora* (*Nectria*) *flammea* (anamorph *F. coccophilum*). Both species are also associated with Diaspididae from warm temperate and tropical

regions (Rossman & Samuels 1999), and have been known in New Zealand from 1926 and 1923, respectively (Landcare Research database 2005).

Both of the above species produce orange sporodochia on the surface of infected scale insects. Red perithecia subsequently develop and tend to occur around the edge of the scale caps of diseased insects. Up to 12 perithecia may develop around a single insect (Booth 1971). Porcelli & Frisullo (1998) found that in Italy *C. aurantiicola* survived the hot, dry season as mycelium in the dead body of the host, and spread by conidia carried on crawlers. There, the fungus was able to kill about 50% of scales.

A study was initiated to increase understanding of the two *Cosmospora* entomopathogens on Diaspididae in New Zealand. The first objective was to obtain new knowledge on the distribution and host range of these fungi within New Zealand. The second objective was to collect new isolates of these entomopathogens, with a view to the identification of new strains as potential biocontrol agents for armoured scale insects. This paper reports the results of the host-range study.

METHODS

Collection of armoured scale insects

During October 2002–February 2003, five forays were made in search of infected scale insects in the Northland, Auckland, Bay of Plenty, Hawke's Bay and Nelson regions of New Zealand. Random searches were made along or near track margins using foreknowledge of likely scale insect-host plant associations to narrow the target plants, which were then examined with a hand lens. The dates and locations of these collections were as follows:

1. Northland, 25–26 November 2002, 4 sites (Puketi Mokau Reserve; Puhoi Far North Reserve; two commercial citrus orchards; Professor W.R. McGregor Reserve Waipoua).
2. Auckland, 3–8 October 2002, 2 sites (Olive Davis Scenic Reserve, Manurewa; Dairy Flat).
3. Bay of Plenty, 23–24 October 2002, 6 sites (commercial macadamia orchard; Waioeka Gorge 5.1 km S of Aroaro Bridge; Kohi Point Walkway between Ohope Beach & Whakatane; Kaiate Falls; McLaren Falls; McLaren Falls Park at the entrance to Waterfall Bush Walk).
4. Hawke's Bay–Taupo, 6–8 November 2002, 6 sites (Maraetotara Falls; Mohi Bush Maraetotara; Maraetotara Gorge Scenic Reserve; Elsthorpe Scenic Reserve; Blowhard Bush Kaweka Ra; Waituhi Saddle Lookout).
5. Northwest Nelson (10–15 February 2003), 3 sites (Eves Valley Scenic Reserve; Kaihoka Lakes Scenic Reserve; Payne's Ford Scenic Reserve Takaka). Other sites visited and searched were Hawke's Lookout on Takaka Hill, Harwood's Hole track, Pupu Springs Reserve, Wainui Falls track, Pigeon Saddle, the Cobb Valley, and Flora Saddle.

In addition to the scales collected on these forays, one sample of infected scale insects was collected by N. Martin (Crop & Food Research) on 5 November 2002 from Hinewai Reserve, Banks Peninsula, Canterbury.

Collection and identification of scale insects

Infected scale insects were most often found on trunks and branches of host trees and were removed by cutting out small pieces of bark, which were placed in paper bags and kept cool for return to the laboratory. Uninfected scale insects from the same site were collected for identification, preserved in 75% ethanol before slide-mounting, and then identified to species by comparing with specimens in the New Zealand Arthropod Collection (NZAC). The slides were deposited in the NZAC.

Identification of entomopathogens

Fungi from infected scales were isolated into pure culture by transferring small portions of sporodochia or perithecia on to potato dextrose agar (PDA) modified with streptomycin sulphate (100 µg/ml) and ampicillin (250 µg/ml) to inhibit bacterial growth. The isolated fungi were identified by the formation and shape of the conidia, culture characteristics

and growth rates at 25°C and 30°C on PDA (Booth 1971). Cultures of *C. aurantiifolia* and *C. flammea* isolated from diseased insects are held in -80°C storage at the Mt Albert Research Centre of the Horticulture and Food Research Institute of New Zealand.

RESULTS AND DISCUSSION

Previous host records (worldwide) of *Cosmospora aurantiicola* and *C. flammea* are shown in Tables 1 and 2, respectively.

TABLE 1: Host records and common names for *Cosmospora aurantiicola* (anamorph *Fusarium larvarum*) recorded worldwide. Note that records include the synonyms *Nectria aurantiicola* and *Sphaerostilbe aurantiicola*.

Host	Common name	Reference	Found in current survey?
<i>Aonidiella aurantii</i>	California red scale	Moore 2002	No
<i>Chionaspis heterophyllae</i>	pine needle scale	ScaleNet database 2005	No
<i>Chrysomphalus aonidum</i>	Florida red scale	Moore 2002	No
<i>Diaspidiotus ostreaeformis</i>	oystershell scale	Hornok & Kozar 1984	No
<i>Diaspidiotus perniciosus</i>	San Jose scale	CMI Descriptions 1981a	No
<i>Hemiberlesia lataniae</i>	latania scale	Landcare Research database 2005	No
<i>Hemiberlesia rapax</i>	greedy scale	Landcare Research database 2005	No
<i>Hemiberlesia</i> sp.	-	-	Yes
<i>Lepidosaphes beckii</i>	purple scale	ScaleNet database 2005	No
<i>Lepidosaphes gloverii</i>	Glover scale	ScaleNet database 2005	No
<i>Leucaspis</i> sp.	-	-	Yes
<i>Melanaspis obscura</i>	obscure scale	ScaleNet database 2005	No
<i>Pseudaonidia duplex</i>	camellia scale	Hsiao & Hsu 1985	No
<i>Suturaspis archangelskyae</i>	almond scale	Cozzi et al. 2002	No
<i>Tagionia vitis</i>	black oak scale	Baldacchino & de Corato 2004	No
<i>Unaspis citri</i>	citrus snow scale	ScaleNet database 2005	No
unidentified	-	-	Yes

In the current study, *Cosmospora aurantiicola* was found on *Hemiberlesia* sp., *Leucaspis* sp. and several unidentified Diaspididae. In this survey it was only found in the Auckland, Bay of Plenty and Gisborne regions. Previous surveys also recorded this species from *Hemiberlesia lataniae* in Northland (J. Charles, pers. comm.).

Cosmospora flammea was found on *Aspidiotus nerii*, *Hemiberlesia lataniae*, *Hemiberlesia* sp., *Leucaspis brittini*, *Leucaspis* sp., *Pinnaspis dysoxylis* and several unidentified Diaspididae. It was also found on *Eriococcus cavelli*, the first time this pathogen has been recorded from Eriococcidae. This species was found in the Auckland, Bay of Plenty, Canterbury, Hawke's Bay-Taupo and Northland regions.

Host-plant associations of the scale insects included *Actinidia* sp., *Alectryon excelsis* (titoki), *Aristotelia serrata* (wineberry), *Brachyglottis repanda*, *Carmichaela australis*, *Carpodetus serratus*, *Coprosma grandifolia*, *Dysoxylum spectabile*, *Hoheria populnea*, *Macadamia* sp., *Macropiper excelsum*, *Melicactus ramiflorus* (mahoe), *Myrsine australis*, *Nothofagus fusca*, *Ulex europaeus* (gorse), *Vitex lucens* (Puriri) and *Salix X reichardtii* (pussy willow).

TABLE 2: Host records and common names for *Cosmospora flammea* (anamorph *Fusarium coccophilum*) recorded worldwide. Note that records include the synonym *Nectria flammea*.

Host	Common name	Reference	Found in current survey?
<i>Aonidia lauri</i>	laurel scale	ScaleNet database 2005	No
<i>Aonidiella aurantii</i>	California red scale	Gao & Ouyang 1981	No
<i>Aonidiella citrina</i>	yellow scale	Gao & Ouyang 1981	No
<i>Aspidiotus destructor</i>	coconut scale	ScaleNet database 2005	No
<i>Aspidiotus nerii</i>	Oleander scale	CMI Descriptions 1981b	Yes
<i>Chrysomphalus aonidum</i>	Florida red scale	Gao & Ouyang 1981	No
<i>Diaspidiotus peniciosus</i>	San Jose scale	ScaleNet database 2005	No
<i>Hemiberlesia lataniae</i>	latania scale	ScaleNet database 2005	Yes
<i>Hemiberlesia</i> sp.	-	-	Yes
<i>Hemiberlesia rapax</i>	greedy scale	CMI Descriptions 1981b	No
<i>Leonardianna pimentae</i>	-	ScaleNet database 2005	No
<i>Leucaspis brittini</i>	-	-	Yes
<i>Leucaspis</i> sp.	-	-	Yes
<i>Melanaspis obscura</i>	obscure scale	ScaleNet database 2005	No
<i>Pinnaspis dysoxyl</i>	-	-	Yes
<i>Pseudaonidia duplex</i>	camellia scale	ScaleNet database 2005	No
<i>Pseudaonidia trilobitiformis</i>	trilobite scale	ScaleNet database 2005	No
<i>Pseudaulacaspis pentagona</i>	white peach sale	CMI Descriptions 1981b	No
<i>Unaspis yanonensis</i>	arrowhead scale	Gao & Ouyang 1981	No
unidentified	-	-	Yes

Aspidiotus nerii, *Hemiberlesia* sp., *Leucaspis brittini*, *Leucaspis* spp., *Pinnaspis dysoxyl* and *Eriococcus cavelli* (Eriococcidae) can be recorded as new host species for *C. flammea*. *Hemiberlesia lataniae* is reconfirmed as a host.

The study has shown that *C. flammea* and *C. aurantiicola* are widespread throughout the country and are capable of infecting both native and introduced species of Coccidae. Although it is not possible to assess from this study the extent to which populations of scale were infected, the ease with which they were found suggests that the suppression of colonies in the wild may be significant. *Cosmospora flammea* was the more prevalent of the two species. It has a wider host range than *C. aurantiicola* and is distributed more widely throughout the country. The latter species was confined to the warmer parts of New Zealand suggesting that it is less adapted to cool conditions than *C. flammea*.

Accessions of both species are currently being screened for pathogenicity to *Hemiberlesia lataniae*, *H. rapax* and *Aspidiotus nerii* to assess their potential for commercial development as biological control agents.

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