Identifying new associations between aphids and Pinaceae using plant sentinels in botanic gardens

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Abstract

As part of a wider intent to develop a plant sentinel network involving botanic gardens and arboreta throughout New Zealand, we undertook a study of host-herbivore relationships in the pinetum of the Christchurch Botanic Gardens. Such a network could greatly assist with risk assessments and surveillance for border biosecurity by allowing investigation of host preferences and new associations, as well as early detection of incursions. Here, our objective was to determine the host range and host specificity of invasive alien aphid species by studying their abundance on *Pinus* species and other Pinaceae of differing Northern Hemisphere origin. Aphids were not restricted to tree species of their home range, and some species had not previously been identified as potential hosts of certain aphids. Such findings allow us to assess the possible impacts of novel insect-plant interactions that are likely to occur when invasive herbivorous insects colonise new host plants outside of their native range.

Keywords

Alien invasive species, aphids, border biosecurity, botanic gardens, pine, Pinaceae, plant sentinels

Introduction

Botanic gardens and arboreta as we know them today were typically founded on the study, use and display of plants collected from other countries and continents, rather than those of their local floras. Each resulting plant collection constitutes a heterotopia as the world's plants are brought together at one location for public enjoyment and education. These diverse "expatriate" collections, relatively well documented and curated in long-lived, networked institutions, also offer unparalleled opportunities for the study of their associated biodiversity, including potential pests and diseases. As such they can contribute to the International Plant Sentinel Network by giving early warning of potential biosecurity problems associated with the host plant species in their countries of origin (Britton et al., 2010; Kramer & Hird, 2011). Trees of the family Pinaceae are among the plant taxa that are of particular interest because they are a species-rich group that is often dominant in forests, particularly in boreal and temperate regions (Farjon, 2001). Furthermore, several Pinaceae species are important in forestry in both natural and planted forests, especially certain species in the genera *Pinus* (pine), *Picea* (spruce), *Pseudotsuga* (Douglas fir), and others.

The Christchurch Botanic Gardens (CBG), established in 1863 in Christchurch, South Island, New Zealand, have a pinetum containing numerous Pinaceae and other gymnosperm taxa. There is good representation of members of the Pinaceae originating from North and Central America, Europe, and central and eastern Asia, especially of the genus *Pinus* for which there was also a broad range in phylogenetic relatedness, with about 50 species. A tremendous diversity of insect species is associated with pines, including some important pests that are of major concern to forest health (e.g., Ohmart, 1980; de Groot & Turgeon, 2000; Bentz et al., 2010). Here our objective was to conduct a survey of invasive aphids that are a biosecurity problem for crop and native plants in

New Zealand (Teulon & Stufkens, 2002). Several aphids are known to be important pests of Pinaceae (e.g. Day & McClean, 1991; May & Carlyle, 2003), and it is of considerable interest to determine which conifer species are potentially threatened when these species invade new biogeographic regions.

Methods

Trees in the genera *Pinus* (subgenera *Pinus* and *Strobus*), *Abies*, *Picea*, and *Cedrus* of different biogeographical origin were sampled during December 2012 – January 2013 (summer). There are over 200 species of these genera in the CBG, according to the plant database which was used to locate trees selected for sampling. Where possible, tree species were chosen for which more than one tree per species was held, to provide as much replication as possible. Aphids were identified using reference collections, and numbers present recorded. Several other genera for which only one tree of one species was present were also sampled.

Results and discussion

Our aphid survey at Christchurch Botanic Gardens yielded more than 4700 aphid individuals from the conifers we sampled. According to our preliminary analysis, these represented five aphid species and 30 individuals that were unidentified. The vast majority of specimens collected were introduced aphids of four species known to be established in New Zealand: the spruce aphids *Cinara pilicornis* and *Elatobium abietinum*, and pine aphids *Essigella californica* and *Eulachnus brevipilosus*, as well as a single specimen of the lily aphid *Neomyzus circumflexus*. The fact that most aphids collected from Pinaceae were established exotic species is consistent with the fact that most of the trees we sampled are introduced species. There are no native Pinaceae in New Zealand (Dawson & Lucas, 2011), as in most of the southern hemisphere, and it is therefore not surprising that almost all of the insects associated with these trees in New Zealand originated from other parts of the world where these trees and their associated entomofauna are native. For example, both pine aphids *Essigella californica* and *Eulachnus brevipilosus*, first detected in New Zealand in 1998 and 1960, respectively, were abundant on species of *Pinus* native to their countries of origin, but were also found on some new hosts.

Our preliminary results indicate that phylogenetic and geographic effects were generally consistent with known host-aphid associations although there were also unexpected associations that are the subject of ongoing analyses. Due the lack of replication of some tree species we were not always able to apply standard statistical analyses to species-level data. This difficulty could be overcome, and greater value added to such studies, by pooling information from multiple gardens and arboreta. If such a collaboration were well planned and coordinated, it should be possible to achieve adequate replication for many species. Biogeographical and climatic effects could also be investigated. Our findings offer encouraging support for the work of the International Plant Sentinel Network and results that could be applied for enhanced risk assessment and better border biosecurity.

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