Biological control of giant willow aphid

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Vespid wasps and a ladybird beetle feeding on honeydew under a giant willow aphid colony.

Tiny wasp appears to be doing its job

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The biological control agent, *Pauesia nigrovaria*, a tiny parasitoid wasp from California, was released throughout New Zealand in 2020 and 2021 with the aim of restoring the health of willows (Fig 1a). Willow species are important trees for slope and riverbank stabilisation, crop and livestock shelter, fodder, and as a critical early season source of pollen and nectar for honeybees. Since 2013, willows in New Zealand have been plagued by the invasive giant willow aphid, *Tuberolachnus salignus* (or GWA). These aphids tend to manifest in massive populations, depleting the trees of nutrients and moisture, resulting in initial dieback and occasionally tree death after successive infestations. Not only are the aphids metabolising vast amounts of sap and emitting kilograms of carbon per tree, the damage to willows reduces their ability to sequester carbon and store it in their biomass. This would equate to a large loss in carbon sequestration, given the area of planted and naturally occurring willows in New Zealand.

The aphids cause yet another problem. Giant willow aphids secrete copious amounts of honeydew as they feed, causing sooty mould growth on and beneath infested trees. Vespid wasps thrive on this sugary honeydew and they create hazards for people and animals, causing apiary losses, and without doubt generating other unmeasured ecological impacts. What was once primarily a beech forest issue with vespid wasps has become a ubiquitous one since willows are widespread in the New Zealand landscape.

The good news is that *P. nigrovaria* appears to be doing its job. Despite the discovery of hyperparasitism in 2021, whereby natural enemies of other aphid parasitoids were found attacking *P. nigrovaria*, the biological control agent appears to be prevailing. This is evidenced by our continued ability to locate freshly mummified giant willow aphids with relative ease. Detections of GWA mummies, made primarily during 2022 surveys of the North Island, have been documented on the web-based citizen science platform, iNaturalist (Fig 1b).

To quantify early impact of *P. nigrovaria*, giant willow aphid population levels have been measured at five North Island release sites, at the time of release in 2020 and again one and two years later. An abundance scale from 0 (no aphids) to 4 (one or more large colonies more than 10 cm in length) was used to score between 10 and 20 trees at each site, and the proportion of each abundance score at each site was calculated. Figure 2 shows the average proportions

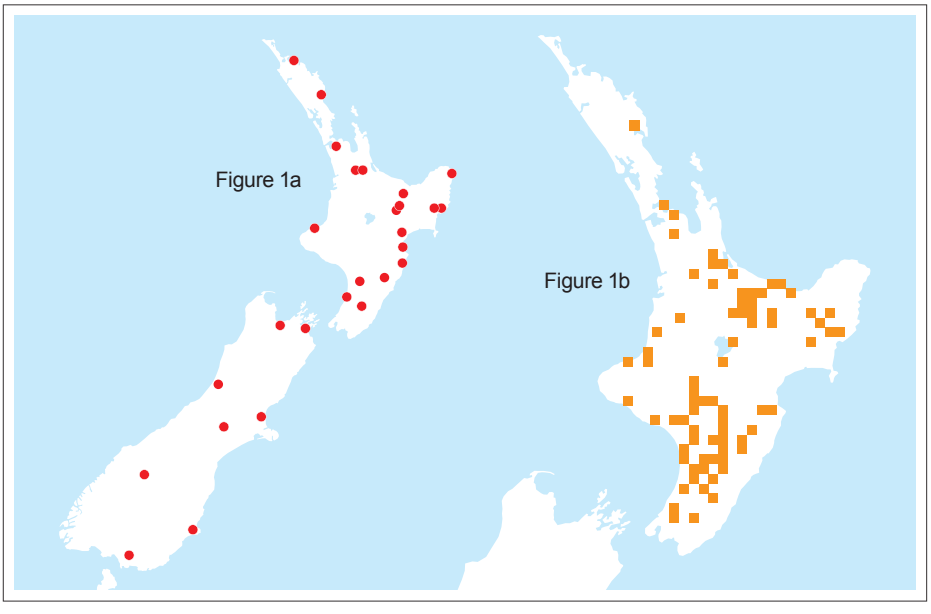

Figure 1a. *Map of New Zealand showing* Pauesia nigrovaria *release sites (red dots).*
Figure 1b. *New Zealand's North Island showing locations where giant willow aphid mummies have been found and recorded on iNaturalist.*

across all five sites, illustrating that overall, aphid abundance has decreased each year, and the proportion of aphid-free trees has increased from 30% at the time of release to 86% two years later. Monitoring of these sites for an additional year would allow for more robust statistical analysis of these trends, and we are currently exploring potential funding opportunities to do so.

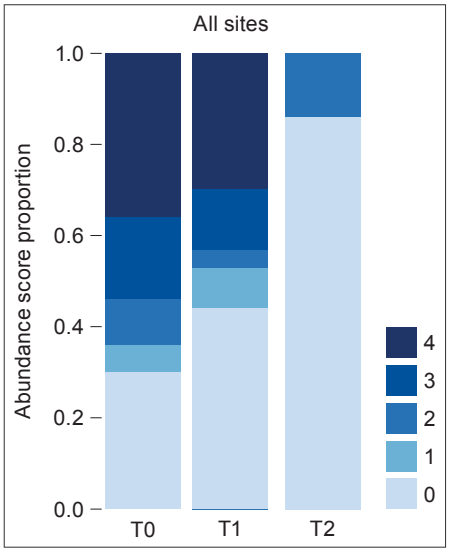

Figure 2. *Proportion of giant willow aphid abundance scores averaged across all sites over 3 years (T0 = time of release, T1 = after 1 year, T2 = after 2 years). Abundance scored as follows: 0 = no aphids, 1 = one or more lone aphids, 2 = one or more aphid colonies less than 5 cm in length, 3 = one or more aphid colonies between 5 and 10 cm in length, 4 = one or more aphid colonies longer than 10 cm.*

Mummified remains of giant willow aphids parasitised by P. nigrovaria *in the Bay of Plenty.*

Anecdotal evidence (primarily through personal communication to S. Sopow) also suggests a drop in aphid numbers and associated issues in 2022 in several locations, particularly those in proximity to release sites. However, we are also still receiving some reports of ongoing problems with giant willow aphid. Biological control can be highly effective, but almost always takes many years for the full benefits to be realised. The ability of *P. nigrovaria* to rapidly proliferate and to persist in the face of natural enemies, along with its capacity for long distance spread (up to 100 km within one year has been documented) bode well for this to be a success story, and for New Zealand to realise the benefits much more quickly. Indeed the results to date have exceeded our expectations and it is phenomenal to see such positive outcomes this early in a biological control programme.

I (Stephanie) would like to express my appreciation to the fantastic project team that has supported this project: Barry Foster (Apiculture NZ, Project Chair), John McLean (Apiculture NZ), Trevor Jones (Plant & Food Research), Bruce Crabbe (Bay of Plenty Regional Council), Elaine Gould (formerly of Zespri International), and Jessie Bong (Zespri International).

Key project team members from left to right: John McLean (Apiculture NZ), Stephanie Sopow (Scion), Trevor Jones (Plant & Food Research), Peter Marshall (Terra Preta Truffles, NSW, Australia) and Barry Foster (Apiculture NZ).

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