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Biological control of the elm leaf beetle

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Summary

The elm leaf beetle is causing major foliage damage to the elm trees of the Mornington Peninsula and Berwick. Two parasitoids are being considered as potential classical biological control agents, and one of these, a eulophid egg parasitoid, *Tetrastichus gallerucae*, has been shown to be specific to elm leaf beetle, when tested against chrysomelids introduced as biological control agents of weeds and some Australian native chrysomelid species, and has been released at three sites. The second parasitoid, a tachinid fly, *Erynniopsis antennata*, is also host specific and has been approved for release.

Introduction

The elm leaf beetle, *Pyrrhalta luteola* (Muller), is native to Europe, north Africa and Eurasia. It was introduced into USA in about 1837 and by 1883 was widespread in the northeast of the country (Essig 1958). By 1908 it had entered the United States midwest (Howard 1908) but serious infestations in California did not occur until the 1970's (Luck and Scriven 1976, 1979). The beetle was first found in Australia in February 1989 on the Mornington Peninsula in Victoria (Osmelak 1990). However, because of its high density at some locations, it is likely that the infestation had been present in the area for at least 14 years. Elm leaf beetle has not been recorded in Australia outside a 100 km radius to the south east of Melbourne.

In the spring, adult beetles emerge from their sheltered overwintering sites and cause feeding shot-holes in the leaves of elm trees (*Ulmus* spp.). Severe leaf damage can occur even before egg laying begins and larvae commence feeding. The larvae skeletonize leaves during summer and can cause complete defoliation of large elm trees, particularly English elms (*U. procera*), which appears to be the most susceptible species. Such defoliation occurs to English and golden elms (*U. glabra* 'Lutescens') on the Mornington Peninsula. Elm leaf beetles have the potential to cause severe damage to the elm trees of Melbourne which have an estimated value of $30 million (Osmelak 1990).

The aims of the research project undertaken at the Keith Turnbull Research Institute were to develop management strategies to suppress population numbers of the elm leaf beetle on the Mornington Peninsula, prevent extensive damage to elm trees and delay the spread of the elm leaf beetle towards the city. The project, which commenced in May 1990, was structured into four main areas: biological control, elm leaf beetle life history, chemical control studies, and an elm leaf beetle distribution survey.

In this paper the progress towards classical biological control of elm leaf beetle is discussed.

Biological control of elm leaf beetle

In North America, a range of generalist predators (e.g., birds, frogs, mantids, lacewings and bugs) have been recorded as preying on elm leaf beetles and at times a fungal disease, when the humidity is high, causes considerable mortality. The introduction, release and management of natural enemies obtained from Europe has, however, received major attention throughout North America, largely because of the ineffectual nature of generalist predators and chemical control measures. This process, of introducing natural enemies from the source of the pest, is known as classical biological control.

In Melbourne, the elm is a very important ornamental tree, being widely planted in city parklands and streets and the golden elm is still widely planted in private gardens. Because of the size and abundance of elms in heavily populated urban areas, extensive use of pesticides as foliar treatments may be ineffectual and socially undesirable. The focus has therefore been on biological control, potentially a safe, permanent solution to the aesthetic injure caused by these beetles. Five principal steps are undertaken to implement classical biological control:

i. identifying the most important controlling factors in the country of origin of the pest,
ii. importation of the natural enemies into quarantine in Australia,
iii. host specificity testing against Australian native and introduced fauna (usually fauna closely related to the target pest),
iv. mass rearing and release of the biological control agent and

v. evaluation of the impact of the agent.

The biological control program in Victoria began in 1990 and relied heavily on expertise in California for agent shipments and technical advise.

Biological control of elm leaf beetle was first attempted in USA in 1907 by the importation and release, from France, of a tiny wasp, *Tetrastichus gallerucae* (Fonscolombe), that parasitizes the elm leaf beetle eggs (Clausen 1956). This parasitoid has been reared from eggs of the elm leaf beetle in France, Spain, Iran, Morocco, Greece and Israel and Asia. Introductions into North America, from a number of sources, resumed during the 1960s and continued in the 1970s and 1980s. *T. gallerucae* has now become established in Ohio (Hall and Johnson 1983) and California (Dahlsten *et al.* 1989) and may have considerable potential when used in inundative release programs (Ehler *et al.* 1987). In Northern California in 1989 over 85% of the eggs of elm leaf beetle in the town of Marysville were parasitized two years after release of *T. gallerucae*. However, at many release sites the parasitoid has failed to overwinter.

T. gallerucae, in addition to direct parasitism of as high as 95% of elm leaf beetle eggs, also causes egg mortality through host feeding behaviour, where adult wasps puncture eggs and consume the exuding contents. In Europe, *T. gallerucae*, is synchronized with the emergence and oviposition of elm leaf beetles in the spring (Howard 1908). Single eggs are laid into the eggs of elm leaf beetles and in 18–20 days, at 24–26°C, adult parasitoids emerge from the elm leaf beetle eggs (Clair *et al.* 1987). Under field conditions several generations would be completed each season as long as host eggs are available for parasitism. Adult parasitoids overwinter in sheltered situations and emerge in the spring to attack the newly laid elm leaf beetle eggs.

The genus *Tetrastichus* is a large genus containing both primary and secondary parasitoids. A number of *Tetrastichus* species have been introduced into Australia as control agents, including *T. giffardianus* Silvestri for Mediterranean fruit fly control (1936), *T. ceroplastae* (*Girault*) for control of wax scale (1971), *T. brontispae* (Ferriere) for control of palm leaf beetle (1981) and *T. phyllocnistoides* Narayanan for control of citrus leaf miner (1985).

T. gallerucae, was introduced from California into the quarantine laboratories at the Keith Turnbull Research Institute in June 1990. For five months it underwent extensive tests to determine its capacity to attack other species. Eggs of two species from the same subfamily as *Pyrrhalta* (subfamily Galerucinae), eight species from the subfamily Chrysomelinae and three from the subfamily Halticine were screened in the tests involving *T. gallerucae*. The wasp was found to only attack elm leaf beetle, there being no threat to any of our native or introduced beneficial insects or any other species. Commonwealth approval to release the parasitoid was granted and releases commenced at Mt. Eliza in December 1990 and at Berwick in February 1991. Over 3200 wasps were released in November 1991 at Mt. Eliza, Berwick and Morning-ton. A further 1600 parasitoids were released over the same sites in 1992. Regular monitoring of elm leaf beetle at the Mt. Eliza site indicated that elm leaf beetle eggs were being parasitized by *T. gallerucae*. Although it appears that *T. gallerucae* can survive and reproduce over the spring/summer period, its survival from one season to the next has yet to be proven.

Other biological control agents have been established on elm leaf beetle in California with a tachinid fly, *Erynniopsis antennata* (Rondani), causing high levels of larval parasitism late in the summer (Luck and Scriven 1976, Dahlsten *et al.* 1989). The genus *Erynniopsis* is in the Tribe Blondeliini which has hosts from the Blattodea, Orthoptera, Phasmatodea, Coleoptera, Lepidoptera and Hymenoptera. A number of species from the Tribe have been used as biological control agents, including *Compsilura* sp. for control of gypsy moth in North America. *E. antennata* parasitizes mature larvae, either killing the larvae before the elm leaf beetle larvae pupate, or remaining as a first instar maggot throughout the pupal and overwintering adult stage of the elm leaf beetle (Flanders 1940). In the latter case the fly emerges from the elm leaf beetle adult soon after the beetles commence feeding on the spring growth. In a survey of northern California cities in the mid 1980s, 25% of the cities had elm leaf beetle populations where the apparent maximum parasitism by *E. antennata* was over 40% (Dreistadt and Dahlsten 1990). Many of these *E. antennata* populations were heavily parasitized by a pupal parasitoid, *Tetrastichus erynniae*, which may have been limiting the effectiveness of the fly. This tachinid has considerable potential to reduce elm leaf beetle numbers in Australia, particularly if released without its hyperparasite.

In July 1991, *E. antennata* was introduced into quarantine, the hyperparasites eliminated, and the fly subjected to host specificity testing to determine its host range. Larvae of nine species from the subfamily Chrysomelinae and one from the subfamily Halticine were screened in the tests with *E. antennata*. The fly has since been found to be host specific and approved for release but sufficient numbers have yet to be produced under quarantine conditions for release.

Conclusions and future directions

The elm leaf beetle will be a mounting problem to elm trees throughout the City and suburbs of Melbourne and will continue to spread throughout Victoria and interstate. The future reduction of heavy foliage damage is likely to be dependent on the widespread establishment of biological control agents as widescale foliar treatments with chemicals do not seem practicable. If the two parasitoids become widely established there is the possibility that the damage caused by elm leaf beetle will become less severe and chemical control measures may become unnecessary. As elm leaf beetle appears to be largely univoltine in Melbourne, with few eggs being laid after December, and *T. gallerucae* has no alternative hosts, the parasitoid may have difficulty establishing and surviving through summer and winter to recommence parasitism in November. Releases of *E. antennata* will be a priority for the biological control program over the next few years.

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Carbaryl trunk banding for control of elm leaf beetle (Coleoptera: Chrysomelidae) in Victoria

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Abstract

An application of 2% (20 g L^{-1} a.i.) carbaryl solution applied as a bark band just prior to elm leaf beetle larvae descending elm trees produced a greater than 90% mortality of prepupae for five weeks, which declined to 72% seven weeks after insecticide application. A repeat insecticide application was necessary to maintain high mortality levels for the duration of the trial. Mean egg clusters on treated English and golden elms were significantly lower than control trees the following seasons after treatment. Foliage damage on treated trees was reduced in the second and third years of the study on English and golden elms.

Introduction

Elm leaf beetle, *Pyrrhalta luteola* (Muller) (Coleoptera: Chrysomelidae), has rapidly become a pest of elms on the Mornington Peninsula and in many municipalities of Melbourne, Victoria. The elm leaf beetle was first discovered in Australia at Mt Eliza, on the Mornington Peninsula, in February 1989, but may have been present for at least ten years.

In 1990, a research project was initiated to develop an integrated management program for elm leaf beetle in Victoria using biological and chemical control techniques. The first biological control agent *Tetrastichus gallerucae* (Fonscolombe) (Hymenoptera: Eulophidae), an egg parasitoid, was imported and released after host specificity testing in 1990. Biological control of elm leaf beetle has been attempted in the United States for more than 80 years (Dreistadt and Dahlsten 1991), however the establishment of parasitoids against elm leaf beetle in Northern California was severely hampered by insecticides for elm leaf beetle control (Olkowski *et al.* 1986). Insecticidal bark banding on tree trunks was subsequently developed in an effort to protect elms from excessive beetle damage without harming biological agents released for elm leaf beetle (Olkowski *et al.* 1986). This method targets elm leaf beetle larvae as they move from the canopy down the trunk to pupate at the base of the tree (Costello *et al.* 1990). The insecticide, usually carbaryl, is sprayed to the bark in a band around the trunk and the larvae contact the insecticide as they move over the band. By reducing the number of beetles emerging as adults, bark banding may reduce foliage damage by later generations of elm leaf beetle and their progeny (Dreistadt and Dahlsten 1990).

A study on the effectiveness of carbaryl bark banding in reducing beetle populations and foliage damage in Victoria

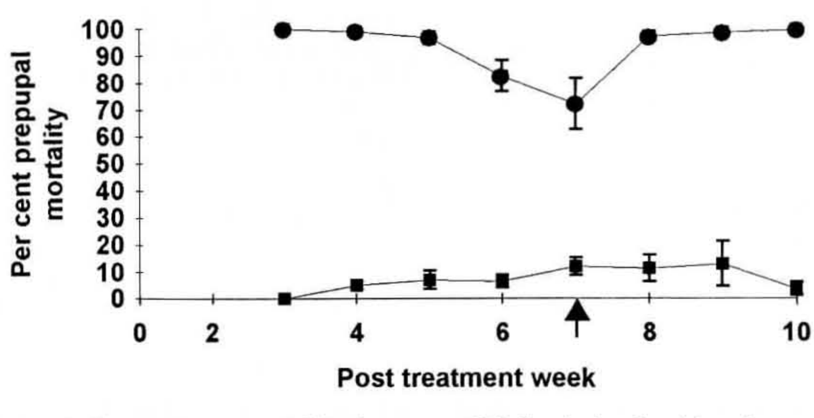

Figure 1. Percentage mortality (mean ± SEM) of elm leaf beetle prepupae collected at insecticide banded (●) and unbanded (■) elms in Mt Eliza 1990–91. Means are significantly different (P=0.001) on all dates. Arrow indicates second banding application. Standard error of means are indicated by the error bars except where obscured by the point.