Elm leaf beetle management symposium

Proceedings of a symposium held at Keith Turnbull Research Institute on February 16, 1994. Sponsered by Nufarm Ltd.

Editor: Raelene M. Kwong, Biological Control Unit, Keith Turnbull Research Institute, Department of Conservation and Natural Resources, PO Box 48, Frankston, Victoria 3199, Australia.

Elm leaf beetle life history and distribution in southern Victoria

Raelene M. Kwong[A] **and Ross P. Field**[B]

[A] Biological Control Unit, Keith Turnbull Research Institute, Department of Conservation and Natural Resources, PO Box 48, Frankston, Victoria 3199, Australia.
[B] Museum of Victoria, PO Box 666E, Melbourne, Victoria 3001, Australia.

Summary

The elm leaf beetle is a recent introduction to Victoria and causes major foliage damage to elm trees of the Mornington Peninsula and in many southern suburbs of Melbourne. Life history studies on the insect indicate that most individuals complete only one generation per year. Accumulated degree-day values (calculated from 1 September), for the peak of each elm leaf beetle life stage, are similar to those determined for elm leaf beetle in California. Monitoring degree-days are used to time foliage applications of the biological insecticide *Bacillus thuringiensis* subsp. *tenebrionis* (Novodor®), trunk banding of the insecticide carbaryl and releases of the elm leaf beetle parasitoids *Tetrastichus gallerucae* and *Erynniopsis antennata*.

Introduction

The elm leaf beetle, *Pyrrhalta luteola* (Muller) is native to Europe, north Africa and Eurasia. It was introduced into the United States around 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 did not occur until the 1970s (Luck and Scriven 1976 1979). The pest status of elm leaf beetle results from defoliation of elms, the reaction of people to the presence of high elm leaf beetle population densities and a tendency of adults to overwinter in houses (Hall 1986). Elm leaf beetle is the third most important forest insect pest in the western United States and fifth in importance nationwide (Kielbaso and Kennedy 1983).

The elm leaf beetle was discovered in Australia in February 1989, about 40 km south of Melbourne at Mt Eliza on the Mornington Peninsula (Department of Conservation and Environment 1991). However, because of high elm leaf beetle densities at some locations, it is likely that the infestation had been present in the area for at least ten years. Establishment of elm leaf beetle in Australia was unexpected, as all forms of elm material have been prohibited imports for many years. Hibernating beetles may have been transported to Victoria by sea, from either north America or Europe, as stowaways in containers or dunnage during the northern hemisphere winter. Upon arrival in Port Phillip Bay, the beetle is likely to have emerged from hibernation in response to the warm Victorian summer, and dispersed to elm trees on the Morn-ington Peninsula (Department of Conservation and Environment 1991). Another explanation may be that the beetles arrived by air with personal luggage.

Distribution in Victoria

In April 1991, a detailed survey of the distribution of elm leaf beetle revealed that the beetle had colonized elms in most parts of the Mornington Peninsula and in the municipalities of Chelsea, Dandenong, Berwick, Pakenham and Waverley. Since then the beetle has been reported in many areas southeast of Melbourne and in large stands of elms in the city centre (Figure 1). In early 1994 elm leaf beetle infestations were detected in the suburbs of Chirnside Park and Caulfield. The beetle is a capable flier but can also be unintentionally spread by travelling in vehicles. On warm days, when elm leaf beetle adults are active, they may enter vehicles parked under elm trees and during the autumn period may crawl into vehicles (cars, caravans, trailers) to hibernate. These "hitchhikers" are therefore able to be spread over large distances in a very short time.

In Australia the most extensive historical elm plantings have been made in New South Wales, Tasmania, South Australia and Victoria (Spencer *et al.* 1991). Given the wide geographical distribution of elm leaf beetle in the United States, it is likely that elm leaf beetle could establish in many areas in Australia where elms are grown.

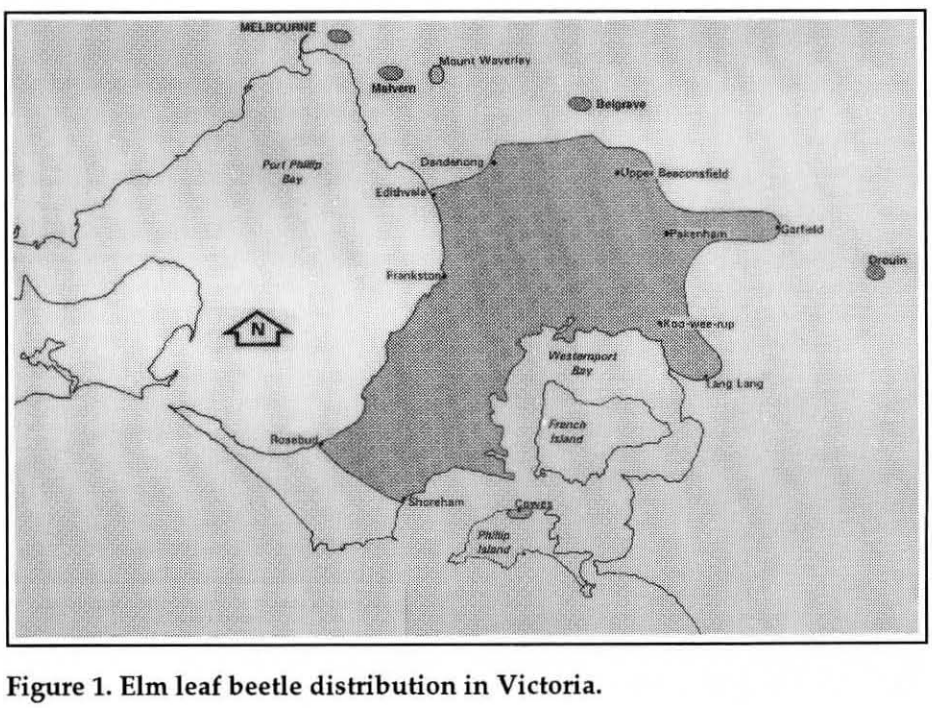

Figure 1. Elm leaf beetle distribution in Victoria.

Hosts

Feeding by elm leaf beetle is generally restricted to elms (*Ulmus* spp.), although Clair (1986) observed feeding on another member of the *Ulmaceae*, the Japanese Zelkova (*Zelkova serrata*), and Browne (1932) found elm leaf beetle damaging almonds and beans growing near defoliated elms. In Victoria, infestations of elm leaf beetle have been found on English elm (*U. procera*), golden wych elm (*U. glabra* 'Lutescens'), Camperdown elm (weeping elm) (*U. glabra* 'Camperdownii'), Dutch elm (*U.* × *hollandica*) and variegated elm (*U. minor* 'Variegata'). Hall *et al.* (1987) found that elm leaf beetle survival and reproduction was high on European elms, moderate on American elms and low on Asiatic species. They concluded that there may be a relationship between the geographic origin of elms and their susceptibility to elm leaf beetle defoliation, with coevolved elms (i.e. European species) being more susceptible than other elm species.

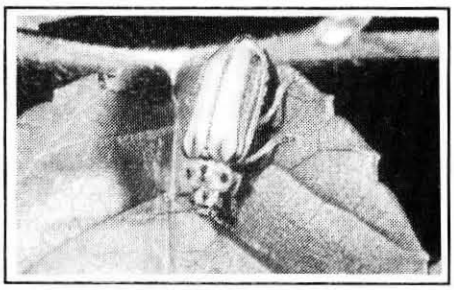

Figure 2. Adult elm leaf beetle.

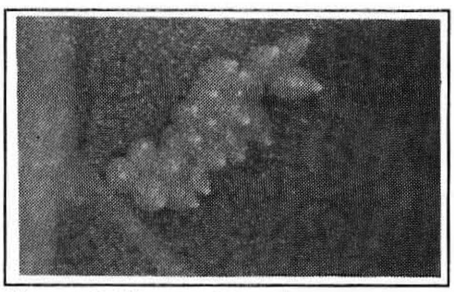

Figure 3. Elm leaf beetle eggs.

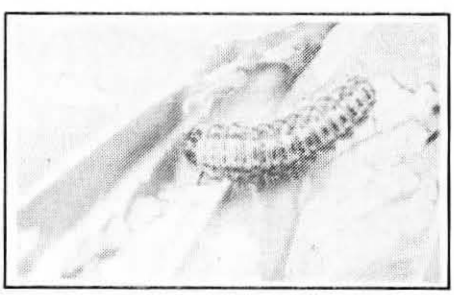

Figure 4. Elm leaf beetle larvae.

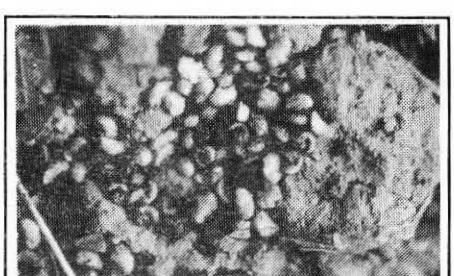

Figure 5. Elm leaf beetle pupae.

Elm leaf beetle identification

Adults

Oblong, 6 mm × 2.1 mm, light yellow to dull green, with several black blotches on the head and thorax, and an indefinite black stripe on the outer margin and wing covers (Figure 2).

Eggs

Yellow, lemon-shaped, approximately 1.2 mm long and 0.6 mm wide, laid in double rows on the underside of elm leaves (Figure 3).

Larvae

Three larval instars with the head, legs, tubercles and numerous setae coloured black. The first instar averages about 1 mm and the final instar 7–12 mm in length (Figure 4).

Pupae

Bright yellow with black setae, oval, about 5 mm long and found on the ground at the base of trees (Figure 5).

Elm leaf beetle life history in southern Victoria

In late October when leaf buds are open on elms, adults emerge from hibernation and begin feeding on young elm foliage causing a shot-hole appearance in leaves. Shortly after mating, eggs are deposited in early November in clusters of about five to thirty on the underside of leaves. Egg laying by these adults usually ceases by January with the peak egg-laying period occurring in early December (Figures 6 and 7).

Larvae emerge from eggs about seven days after being deposited and feed on the epidermis of the underside of the leaves leaving a skeletonized effect. Of the three larval instars, the third instar causes most of the damage and are reputed to consume about five times more leaf area than the second instar and 18 times more than the first instar (Clair 1986). Larvae are found on elms from late November through to mid February (Figures 6 and 7). Heavy skeletonization of the leaves causes them to turn brown and drop prematurely from the tree. When the larvae have completed their development, most will walk down the trunk of the tree to pupate, often exposed, around the base of the trees. In southern Victoria, mature larvae usually begin to descend trees in late December and pupae may be observed through to early March.

Adults emerge about ten days after pupation and feed for a number of weeks before seeking hibernation sites around late March for the winter. Elm leaf beetle adults overwinter in dry sheltered places such as log piles, sheds and houses. When elm leaf beetle densities are extremely high, trees become severely defoliated by late February. The trees attempt to produce new leaves, however these are quickly consumed by adults.

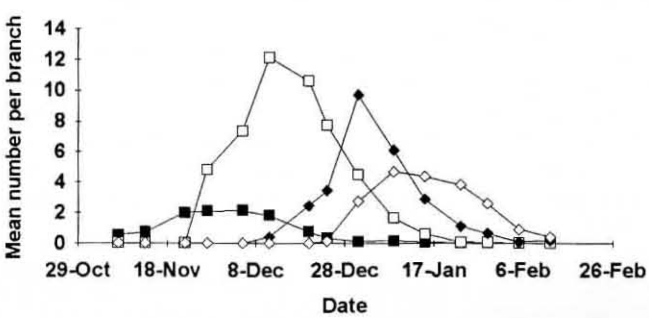

Figure 6. Elm leaf beetle mean egg cluster and larval instar stages per 30 cm branch tip on elms, Marathon Drive, Mt Eliza 1991/92.
Egg clusters (■), 1st instar (□), 2nd instar (◆), 3rd instar (◇).

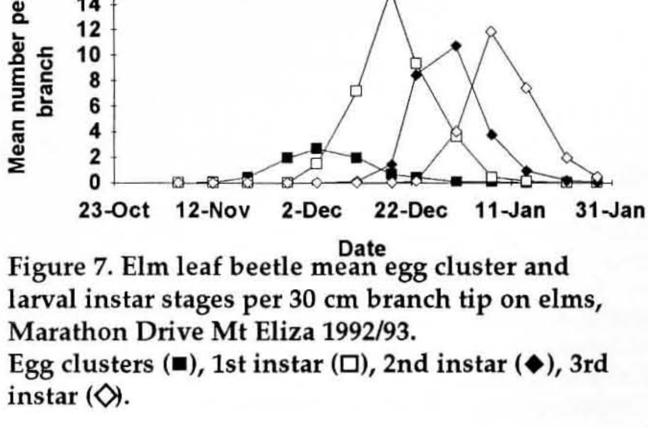

Figure 7. Elm leaf beetle mean egg cluster and larval instar stages per 30 cm branch tip on elms, Marathon Drive Mt Eliza 1992/93.
Egg clusters (■), 1st instar (□), 2nd instar (◆), 3rd instar (◇).

Beetle-feeding weakens the trees and may make them subject to wind breakage or susceptible to infestations of the European elm bark beetle, *Scolytus multistriatis* (Marsham), a vector of Dutch elm disease (Brewer 1973). Although no reports of tree deaths caused by elm leaf beetle have been recorded in Victoria, Felt (1902) blamed elm leaf beetle directly for the death of an estimated 4000 elms in three New York cities.

Life history studies conducted at Mt Eliza since 1990 have shown that elm leaf beetle completes only one generation per season. However, early maturing larvae result in a small second generation in some seasons. The number of generations per year in California varies depending on location and weather (Dahlstan *et al.* 1991). Elm leaf beetle has one or two generations a year in north eastern California, the cooler part of the state, and three or more generations in southern California (Dreistadt *et al.* 1991).

Degree-day development

The duration of each phase of the elm leaf beetle life cycle is dependent on temperature. King *et al.* (1985) found that elm leaf beetle does not feed or develop below temperatures of about 11°C. Temperatures above this threshold temperature are monitored in units called degree-days. The degree-day value for a particular date is a measure of the degree of development that occurred during that period of time. Degree-days for each date can be estimated by subtracting the threshold temperature from the average daily temperature for that date (Dreistadt *et al.* 1991). The equation is:

$C = (max + min)/2 - K$ (Arnold 1960)

where C = degree days (°C), max = maximum daily temperature, min = minimum daily temperature and K = threshold temperature (11°C). This linear degree-day model, despite its limitations, is used widely because it requires minimal data for formulation, is easy to calculate and apply, and often yields approximately correct values (Wagner *et al.* 1984).

Studies by Dreistadt and Dahlsten (1990a), King *et al.* (1985) and Clair (1986) on the influence of temperature on elm leaf beetle development, have enabled a prediction model for the development of each life stage to be developed. Dreistadt *et al.* (1990) determined the degree-days accumulated (above 11°C from 1 March) at the observed peak in the density of elm leaf beetle adults, eggs and larvae in northern California (Table 1).

In Victoria, a study was conducted in 1992 and 1993 to determine the accumulated degree-day values at the peak density of elm leaf beetle eggs and larvae on elms at Mt Eliza. We examined 40 branch terminals, each 30 cm long, on two elms at weekly intervals beginning in November. The numbers of egg clusters and larvae of each instar per branch were recorded and averaged for each tree. The life history studies conducted in 1991/92 and 1992/93 are summarized in Figures 6 and 7 and show the peak period of each life stage. Daily maximum and minimum temperatures were obtained from a weather station in Frankston (approximately 10 km from the study site) in 1992 and from a data logger located at the study site in 1993. Degree-days (above 11°C) were accumulated starting from 1 September and were calculated using a sine wave formula approximation for daily temperature fluctuations (Morse and Strawn 1986). Table 1 shows the accumulated degree-day values for elm leaf beetle at Mt Eliza and compares these with elm leaf beetle in northern California.

Table 1. Degree-days accumulated (above 11°C from 1 March for California and 1 September for Mt Eliza), at the observed peak in numbers of elm leaf beetle eggs and larvae (L1 = first instar larvae, L2 = 2nd, L3 = 3rd) for northern California and Mt Eliza, Victoria. Values in parentheses are dates of accumulated degree-day values.

Stage	Degree-days California 1986	Degree-days Mt Eliza 1991/92	Degree-days Mt Eliza 1992/93
Eggs	274	346 (5 Dec)	289 (3 Dec)
L1	372	382 (11 Dec)	403 (18 Dec)
L2	443	509 (31 Dec)	502 (31 Dec)
L3	560	548 (8 Jan)	551 (7 Jan)

The accumulated degree-day values determined for elm leaf beetle life stages at Mt Eliza were consistent between the two years. The largest difference in degree-day values was between the peak egg clusters, however this difference (57 degree-days) represents only about a week at typical summer temperatures. The dates at which the peak life stages were observed between the two years are also consistent indicating that these two years had similar spring and summer temperatures. The accumulated degree-days for elm leaf beetle at Mt Eliza compare well with elm leaf beetle in northern California. Dahlsten *et al.* (1990) reported that accumulated degree-day values are crude estimates since insect development varies both within and between trees, and that the microclimate in the tree is almost certainly different from the data collected in weather shelters or elsewhere.

Timing elm leaf beetle control treatments

Predicting the seasonal occurrence of insects is essential for accurate scheduling of control tactics (Wagner *et al.* 1984). Monitoring degree-days helps eliminate the guesswork or prolonged sampling otherwise required to determine when specific life stages of the pest are most abundant (Dreistadt *et al.* 1991).

Integrated pest management program for elm leaf beetle

Integrated pest management programs for elm leaf beetle have been developed for use in California (Olkowski *et al.* 1986, Dahlsten *et al.* 1991). They include:

- monitoring procedures that correlate elm leaf beetle population levels with anticipated damage that will permit tree managers to determine if control is necessary,
- implementation of biological control,
- the use of chemical and biological insecticides which are compatible with biological control and
- the use of degree-days for timing treatments.

Components of these integrated pest management programs were implemented in Victoria in 1990 when an elm leaf beetle project was initiated to control elm leaf beetle on the Mornington Peninsula.

Biological control

In California, three elm leaf beetle parasitoid species have been established: a larval and larval-adult parasitoid, *Erynniopsis antennata* (Rondani) (Diptera: Tachinidae), a larval-pupal parasitoid *Tetrastichus brevistigma* (Gahan) (Hymenoptera: Eulophidae) and an egg parasitoid *Tetrastichus gallerucae* (Fonscolombe). *E. antennata* was established near Stocton, California, in 1939 (Flanders 1940) and parasitism of over 40% has been observed (Dreistadt and Dahlsten 1990b). Unfortunately, the effectiveness of *E. antennata* is being limited by the hyperparasite *Tetrastichus erynniae* (Domenichini) (Luck and Scriven 1976). *T. brevistigma* was established in central California in 1934 (Berry 1938), however it is apparently of little benefit in controlling elm leaf beetle (Luck and Scriven 1976). *T. gallerucae* was first imported into the eastern United States in 1908 (Howard 1908) and introductions were made in Ohio and central California from 1932 to 1935 (Dahlsten *et al.* 1991). *T. gallerucae* has established in these states and in southern California it is reported to have significantly reduced elm leaf beetle defoliation (Dahlsten *et al.* 1991).

T. gallerucae and *E. antennata* have been imported into Victoria and Commonwealth approval to release these parasitoids has been granted. Releases of *T. gallerucae* commenced at Mt Eliza in December 1990, and further releases have been made in other elm leaf beetle infested areas in southern Victoria, however establishment has not been achieved. Releases of *E. antennata* are likely to commence in 1994. Degree-days can be used to determine when releases of elm leaf beetle parasitoids should occur. For example, releases of *T. gallerucae* in Victoria should be made at the beginning of elm leaf beetle oviposition, which is around 218 degree-days at Mt Eliza (Figure 8a, b). *E. antennata* parasitizes the mature elm leaf beetle larvae therefore releases should be made at around 500 degree-days when the majority of larvae present in the field are maturing.

Foliage sprays

If a foliar insecticide application is planned, spraying should be carried out at around 380 degree-days to coincide with the peak density of first generation first instar larvae (Figures 8a, b). Application timing is especially critical for *Bacillus thuringiensis* (Bt) subsp. *san diego* or *tenebrionis*, a new biological insecticide, recently registered for elm leaf beetle control in California (Dreistsdt *et al.* 1991). The effectiveness of *B. thuringiensis* subsp. *tenebrionis* (Novodor®) on elm leaf beetle in Victoria is currently being evaluated with the purpose of registering this product for elm leaf beetle control in Australia. Due to the short persistence of Bt, applications must be carefully timed to achieve the best possible results.

Insecticide bark banding

Insecticide bark banding involves spraying the trunk of the tree in a half metre wide band with a 2% active ingredient solution of carbaryl. This method targets the mature larvae as they descend the tree to pupate on the ground. The time for insecticide bark banding at Mt Eliza is in late December, around 500 degree-days, when the mature larvae are about to begin their descent (Figures 8a, b).

Further work needed

Research

Further research into elm leaf beetle biology and ecology is required to understand why elm leaf beetle completes only one generation in southern Victoria. This information will enable the potential voltinism to be determined for elm leaf beetle in warmer areas of Australia, hence the potential national impact of elm leaf beetle.

Further importations of *T. gallerucae* are needed to find a strain that is suited to the climatic conditions of southern Victoria. These strains, which originate from several European countries, are available from California where they have been kept separately to preserve their integrity. Releases of *E. antennata* into Victoria will commence after their hyperparasites, *T. erynniae*, have been eliminated. There is great potential for *E. antennata* as a biological control agent in Australia as it appears to be better synchronized to the elm leaf beetle life cycle than *T. gallerucae* (Dahlsten 1994).

Further research into the efficacy of Novodor® (*B. thuringiensis* subsp. *tenebrionis*) against elm leaf beetle in Australia is required to fulfil registration requirements. Efficient application techniques also need to be developed.

Community education

There are two major owners of elm trees in Australia: local government and the general public. In Victoria it is estimated that 34 000 elms are under municipal control and at least that amount are privately owned. It is imperative that the community is able to identify elm leaf beetle and the damage they cause as the early detection of new isolated infestations may enable them to be eradicated or maintained at a low level. Isolated occurrences should be eradicated where possible but once the infestations become linked, eradication is not possible or feasible. The community needs to be educated about the control methods available to them. They should understand the capabilities and limitations of each control method and their implementation as part of the integrated management program for elm leaf beetle. Finally, since the elm leaf beetle research project in Victoria is funded mainly by community donations, the support and involvement of the community is required for research to continue.

References

Arnold, C.Y. (1960). Maximum-minimum temperatures as a basis for computing heat units. Proceedings American Society for Horticultural Science 76, 682-92.

Berry, P.A. (1938). *Tetrastichus brevistigma* Gahan, a pupal parasite of the elm leaf beetle. US Department of Agriculture Circular 485. 11 pp.

Department of Conservation and Environment (1991). 'Research and Development: Insect pests and Dutch elm disease: threats to elm trees in Victoria'. Scientific Publications and Biometrics, Natural Resources and Systems Division, Research and Development Issue No. 19.

Brewer, J.W. (1973). Control of the elm leaf beetle in Colorado. *Journal of Economic Entomology*. 66, 162-4.

Browne, A.C. (1932). A new host for elm leaf beetle. *Sac., Monthly Bulletin Department of Agriculture* 21(7-9), 347.

Clair, D.J. (1986). Bionomics of the elm leaf beetle *Xanthogaleruca luteola* (Muller), in north-eastern California. Ph.D. Dissertation, University of California, Berkeley. 150 pp.

Dahlsten, D.L. (1994). Elm leaf beetle management – the Californian experience. *Plant Protection Quarterly* Volume 9(2), 42.

Dahlsten, D.L., Rowney, D.L., Tait, S.M. and Gingg, B.J. (1991). Integrated pest management program for the elm leaf beetle, *Xanthogalleruca luteola* Muller. Annual National Conference, Royal Australian Institute of Parks and Recreation. 1, Section 2, 16/1-9.

Dreistadt, S.H. and Dahlsten, D.L. (1990a). Relationships of temperature to elm leaf beetle (Coleoptera: Chrysomelidae) development and damage in the field. *Journal of Economic Entomology* 83(3), 837-41.

Dreistadt, S.H and Dahlsten, D.L. (1990b). Distribution and abundance of *Erynniopsis antennata* (Dipt.: Tachinidae) and *Tetrastichus brevistigma* (Hym.: Eulophidae), two introduced elm leaf beetle parasitoids in Northern California. *Entomophaga* 35(4), 527-36.

Dreistadt, S.F., Dahlsten, D.L., Rowney, D.L., Tait, S.M., Yokota, G.Y. and Copper, W.A. (1991). Treatment of destructive elm leaf beetle should be timed by temperature. *California Agriculture, March-April*. 45(2), 23-5.

Essig, E.O. (1958). 'Insects and mites of the western North America'. (The MacMillan Co., New York). 1050 pp.

Felt, E.P. (1902). Elm leaf beetle in New York State. New York State Museum Bulletin 57, 43 pp.

Field, R.P. and Kwong, R.K. (1992). The biology, control and distribution of elm leaf beetle in Victoria. Unpublished proceedings of Elms: Pests and Disease, a seminar.

Hall, R.W. (1986). Preference for and suitability of elms for adult elm leaf beetle (*Xanthogaleruca luteola*) (Coleoptera: Chrysomelidae). *Environmental Entomology* 15, 143-6.

Hall, R.W., Townsend, A.M. and Barger, J.H. (1987). Suitability of thirteen different host species for elm leaf beetle, *Xanthogaleruca luteola* (Coleoptera: Chrysomelidae). *Journal of Environmental Horticulture*. 5(3), 143-5, September.

Howard, L.O. (1908). The importation of *Tetrastichus xanthomelaenae* (Rond.). *Journal of Economic Entomology* 1, 281-9.

Kielbaso, J.J. and Kennedy, M.K. (1983). Urban forestry and entomology: a current appraisal. *In* 'Urban entomology: interdisciplinary perspectives', eds. G.W. Frankie and C.S. Koehler. (Praeger, New York).

King, J.E., Price, R.G., Young, J.H, Willson, L.J. and Pinkston, K.N. (1985). Influence of temperature on development and survival of the immature stages of the elm leaf beetle, *Pyrrhalta luteola* (Muller) (Coleoptera: Chrysomelidae). *Environmental Entomology* 14, 272-4.

Luck, R.F. and Scriven, G.T. (1976). The elm leaf beetle, *Pyrrhalta luteola*, in southern California: its pattern of increase and its control by introduced parasites. *Environmental Entomology* 5, 409-16.

Luck, R.F. and Scriven, G.T. (1979). The elm leaf beetle, *Pyrrhalta luteola*, in southern California: its host preference and host impact. *Environmental Entomology* 8, 307-13.

Morse, J.G. and Strawn, A.J. (1986). Users manual for degree-day utility (a program on the statewide UCIPM computer system). UCIPM Publication 3, University of California, Davis.

Olkowski, W., Daar, S., Green, M., Anderson, D. and Hyde, J. (1986). New IPM methods for elm leaf beetle. *The IPM Practitioner* 8(5), 1-7.

Spenser, R., Hawker, J. and Lumley, P. (1991). 'Elms in Australia'. p. 1. (Royal Botanic Gardens, Melbourne).

Wagner, T.L., Wu, H-I., Sharpe, P.J.H., Schoolfield, R.M. and Coulson, R.N. (1984). Modelling insect development rates: a literature review and application of a biophysical model. *Annual Entomological Society of America* 77, 208-25.

Biological control of the elm leaf beetle

Ross P. Field[A] and **Raelene M. Kwong**[B]

[A] Museum of Victoria, PO Box 666E, Melbourne, Victoria 3001, Australia.
[B] Biological Control Unit, Keith Turnbull Research Institute, Department of Conservation and Natural Resources, PO Box 48, Frankston, Victoria 3199, Australia.

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