Biology, Ecology and Control of the Eucalyptus Longhorned Borer in Southern California

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Eucalyptus species were first introduced into California in the late 1880s and are presently common in urban settings and woodlots especially in southern and central California. Because they are highly resistant to attack by native herbivores and very tolerant of poor quality soils and drought, it has long been assumed that eucalypts require little care. However, after the eucalyptus long–horned borer *Phoracantha semipunctata* F. was introduced into Southern California in 1984, this situation changed.

In its native Australia, eucalyptus longhorned borer is a minor pest that primarily attacks dead eucalyptus trees and downed limbs. In a number of countries where eucalyptus has been introduced, however, the beetle has eventually followed and become a devastating pest that attacks apparently healthy trees. Such is the case currently in Southern California.

We tested the hypothesis that cold winter temperatures will limit the northward spread of this important pest, and found that temperature did not reduce survivor–ship to adulthood, but an increase in exposure time did result in greater pest mortality. We concluded that the beetle populations are probably capable of persisting in those areas in California where eucalyptus are planted. Drought stress greatly increased susceptibility to attack, apparently by reducing bark moisture content, thereby allowing first instar larvae to penetrate to the cambium. Control of the beetle is currently best achieved through intensive silvicultural management practices: rapid removal of infested trees, providing proper care for trees, and planting resistant *Eucalyptus* species.

Biology of the Beetle

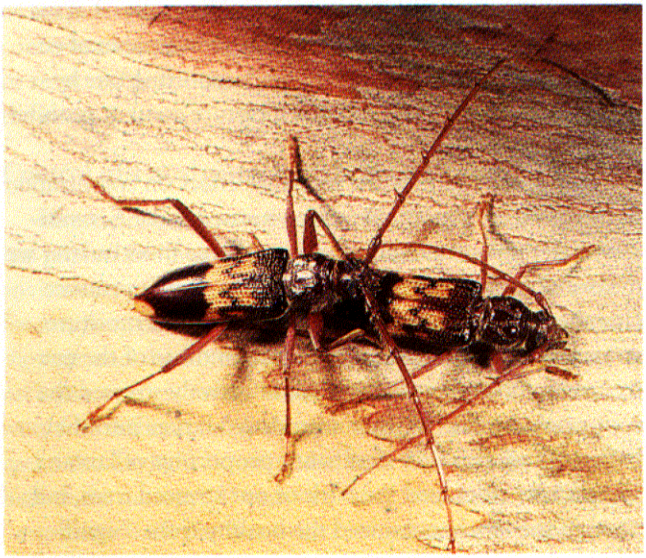
Eucalyptus longhorned borer eggs hatch after 10 days and the first instar larvae bore through the bark to mine along the cambium, also consuming phloem and primary xylem tissues. Larval development requires as little as 2.5 months during the summer. The densities of borer larvae are commonly quite high. We observed that all cambial tissues were often consumed which left the larvae no alternative but to feed on the frass left by earlier larvae. There was an inverse relationship between larval density and survivorship to the adult stage. This decline in survivorship was no doubt due to the lower nutrition of larvae in crowded conditions.

Mature larvae bore into the sapwood to construct a pupal cell, plugging the opening to the surface with frass. Pupation requires 15 days during the summer, but much more time when the larvae overwinter in the pupal cell. Overwintering larvae remain in a dormant stage until late spring, when they commence pupation, and emerge shortly afterwards. The sex ratio among emerging adults was approximately one to one.

Using the natural densities of eucalyptus longhorned borer that we observed in the field, we estimate that a tree of only 30 centimeters in basal circumference could yield as many as 300 adult beetles. This abundance of adults could result from the oviposition of only 6 adult females, assuming 50-percent larvae mortality. Thus, local eucalyptus longhorned borer populations can build to high levels with only a small amount of host material available.

In California, adult eucalyptus longhorned borer appear in late spring. Adults of both sexes show extreme variability in size, with the smallest individuals being only one half the length and one fourth the weight of the largest. Although it has been reported that the adults do not feed, beetles that we had marked often showed increases in weight over the course of weeks, proving that they were consuming something. Microscopic examination of frass from captured beetles revealed that they had eaten eucalyptus pollen. They have also been observed to feed on nectar.

Eucalyptus longhorned borer adults of both sexes were attracted by freshly cut logs. To study their movement in the field, we marked newly emerged adults with paint and released them near a pile of eucalyptus logs that had been attracting wild beetles. Of 50 adults of both sexes released on six dates, not a single individual was recaptured. On the other hand, wild beetles that had been captured and released were commonly recaptured at the release site on subsequent nights. This phenomenon suggests that newly emerged adults have a dispersal phase before beginning to seek hosts for mating and oviposition. We conducted a second experiment in which we captured and marked 550 wild beetles over a three-week period that were attacking three large manna gum (*E. viminalis* Labill.) and released them onto the same trees. Only 20



Eucalyptus longhorned borer

percent were recaptured, again showing that the adult beetles are highly mobile. Using the proportion that were recaptured on subsequent nights we estimated the local beetle population size to be 415 beetles present in the immediate area of the three host trees on any given night. As an example of how attractive host trees are and how responsive the borer populations can be, on a single night we captured nearly 100 adult beetles visiting those three trees. Thus, large numbers of adult beetles may respond to attractive hosts, and there is considerable movement of adults into and out of a given area.

Once on the host, the females were very slow moving in contrast to the highly active males. Apparently males located females by actually contacting them with their antennae. We examined the potential for long-range pheromonal communication by attaching small screened cages to eucalyptus logs with individual beetles of both sexes in half of the cages, and the other cages left empty. There was no significant difference in the number of wild beetles attracted to logs with or without beetles. However, this study needs to be repeated before we can conclusively reject the hypothesis that long range insect-produced attractants are not involved in mate location in this species; factors such as how close the logs were together may have affected the numbers of beetles captured.

Males remained with their mates for up to several hours as the females searched for oviposition sites. During this time the males fought vigorously with any other male they contacted. There was a significantly greater proportion of larger eucalyptus longhorn borer males among mated pairs than observed in the population as a whole, indicating that there was a size advantage in aggressive interactions among the males of this species. There is evidence that the quality of the host material (diameter, phloem thickness, moisture content and colonization density) is a significant factor in the size of the emerging adult; larger beetles emerge from better quality host trees.

On average adult beetles lived for approximately one month in the laboratory, and our mark-recapture data showed a similar longevity among wild beetles. Females oviposited batches of up to 40 eggs in crevices and under loose pieces of bark. The average fecundity in the laboratory was approximately 110 eggs per female over her life span.

There was a conspicuous lack of synchronicity in the emergence of adult beetles even from single logs, which accounts for the lack of discrete generations we observed in the wild population and reported by others. We continuously captured adults on cards coated with an adhesive material, which were attached to logs from early July through mid-September. There were apparently at least two generations per year and the generation time from egg to adult was as short as three-and-a-half months.

Cold Tolerance

The northward distribution of northern hemisphere insects is often limited by annual temperature minima. Because *P. semipunctata* is presumably adapted to the temperate conditions of its native Australia, we predicted that its northward spread may be limited by winter temperatures. We examined the effect of cold temperatures on eucalyptus longhorned borer larval survivorship by subjecting infested logs to temperatures of -5, 0, +5, and +10°C for periods of 1, 3, 7, and 30 days, and to a warm temperature control treatment that was equivalent to summer temperatures. The temperature treatments had no effect on survivorship to adulthood. However, the increasing time of exposure to all temperature treatments did reduce survivorship by as much as 48 percent. The fact that over half of the larvae survived to adulthood in our most extreme temperature regimes of -5°C for one month indicates that eucalyptus longhorned borer populations are probably capable of persisting in areas where winter temperatures drop to freezing or below and thus may be able to colonize any area temperate enough for its eucalyptus hosts.

Host Species Preference

We are currently running surveys at several sites in Southern California to examine the host species preference of eucalyptus longhorned borer. Only two preliminary conclusions can be drawn from these data at this time. The first is that eucalyptus longhorned borer is capable of attacking and killing many species of *Eucalyptus* and that the susceptibility of species can be extremely variable between sites. Susceptibility is strongly influenced by environmental factors that may include water stress (see below), tree age, cultivar, soil type and planting density. These together may make it very difficult to predict which species will be susceptible in a specific site or to rank susceptibility by species. The second conclusion is that the only species that seemed to consistently show resistance to eucalyptus longhorned borer attack was sugar gum (*E. cladocalyx* F. Muell.).

Mechanisms of Host Resistance

It has long been believed that the first line of defense that eucalypts have against eucalyptus longhorned borer attack is the production of kino. This sticky brown gum is an aqueous solution of polyphenolic compounds that are retained in veins or pockets under the bark. Kino is produced by the tree at the site of any injury to the bark and acts as a barrier against fungal attack. Drought stress is the most obvious environmental factor predisposing eucalypts to beetle attack in both California and elsewhere, since it is presumed to be due to the impairment of kino production. However, in at least two *Eucalyptus* species the initiation of kino production requires a minimum of 2 weeks. For this reason, kino seems unlikely to act as an initial defense against colonization by first instar eucalyptus longhorned borer larvae.

We have performed field experiments to examine how eucalypts are defended from eucalyptus longhorned borer. We introduced first instar borer larvae into incisions made in the bark of both logs and standing trees of rose gum (*E. grandis* Hill ex Maiden) and forest red gum (*E. tereticornis* Small). In both species we observed sporadic production of kino at some sites of introduction in the standing trees, but even in the absence of kino, larvae failed to penetrate the tissues of these trees while readily colonizing the cut logs. We attributed this to the high turgidity of the bark tissue in standing trees in comparison to that of logs. In a second experiment, we established two levels of bark moisture content in *E. grandis* logs by standing one group of logs in water while allowing another group of control logs to dry out naturally. Larvae readily colonized the dry logs, but were incapable of entering the bark of the watered logs, supporting our hypothesis that high levels of bark moisture content prohibit beetle colonization.

To further examine the moisture effect on colonization of the bark, we artificially water-stressed three *E. tereticornis* trees by pruning their roots. Three months later we measured moisture stress of those trees with a pressure chamber. The stressed trees showed levels of moisture stress that were 50 percent higher than those of the control trees, indicating that we had effectively stressed the root-pruned trees. We then introduced larvae into the bark of those trees. A significant proportion of larvae successfully colonized the bark of our stressed trees, but none of the larvae colonized the healthy trees. Significantly, there was little evidence of any larvae tunneling in the healthy trees, indicating that larvae were killed, possibly by drowning, very soon after introduction.

The absence of a kino reaction in most of our larval introduction sites demonstrated conclusively that kino does not play a defensive role in the initial colonization of trees by first instar larvae. We further concluded that the moisture content of the bark tissues of healthy trees may be sufficient to prevent the penetration of first instar eucalyptus longhorned borer larvae. Thus, moisture stress plays a very direct role in rendering trees susceptible to borer attack by reducing bark moisture content and allowing larvae to penetrate to the cambium.

Host Attractiveness for Beetles

We have begun to investigate the means by which eucalyptus longhorned borer adults locate their hosts. Preliminary wind tunnel data revealed that adults responded to volatiles emitted by eucalyptus bark. We sampled the volatiles of standing trees (which were not attractive to the beetles) and logs (which were attractive). We collected samples by enclosing the trunks and logs in plastic sheeting and drawing air from inside the bag, trapping the volatile chemicals produced by the tree in a charcoal filter. The volatile components were extracted from the charcoal and separated with a gas chromatograph. The identification of these volatiles is in progress, but we have noted that there was a major difference in the volatile composition of trees and logs; tree volatiles were primarily composed of lighter molecular weight compounds, such as monoterpenes, while aged logs produced a greater proportion of heavier molecular weight compounds, such as sesquiterpenes. The differences in the composition and concentration of volatiles emitted by trees and logs may be responsible for the disparity in their attractiveness to the insect.

Control of Eucalyptus Longhorned Borer

Insecticidal control of eucalyptus longhorned borer has proven prohibitively costly both economically and environmentally, as well as being of limited effectiveness for a variety of reasons: 1) adults are active over much of the year and the outer bark of most eucalypts exfoliates each year, necessitating multiple applications; 2) adults would be difficult to reach with a spray because they spend the daylight hours under bark and may be located high in the canopy; 3) eggs are most frequently laid under loose outer bark patches or in crevices and are therefore difficult to contact with a spray; 4) larvae penetrate through the bark to the surface of the wood and destroy conductive tissues, thus preventing the movement of systemic insecticides; 5) eucalyptus trees are generally large and widely dispersed, making application difficult; 6) trees are often colonized very quickly, with a tree becoming irreversibly damaged in a space of 2-4 weeks; and 7) signs of infestation often go unnoticed until the tree is heavily infested with larvae and nearly dead.

The use of trap trees and logs has proved successful in reducing local populations of eucalyptus longhorned borer. There then arises the problem of disposal of the infested trap tree logs. Anecdotal information suggested that tarping logs for six months will prevent the escape of the adult beetles. To test this theory, we wrapped logs in 6-millimeter black polyethylene sheeting and put those bags in the sun where daily temperatures inside the bag reached 50°C. As a control, another batch of logs were put into screened cages in a partially shaded shed. At the end of two months 60 adults had emerged from the control logs, while only 20 had emerged from the bagged logs. Furthermore, only one beetle succeeded in escaping from the bag. This method was, therefore, effective in both reducing larval survivorship and preventing the dispersal of the adult beetles. Because borer development may be slower at colder temperatures, it will be necessary to leave logs in bags for longer periods of time during the winter to ensure all the adults have emerged. Logs treated in this fashion can then be used for firewood or otherwise disposed of.

Probably the best sustainable long-term method of control of eucalyptus longhorned borer will be through the introduction of natural enemies. In 1988, an Australian parasitoid was introduced into Southern California but apparently has failed to colonize. We hope to attempt another introduction in the near future of one of more species of natural enemies.

At the present time, however, the most effective control against eucalyptus longhorned borer is through intensive silvicultural procedures; 1) bagging or destruction of infested materials before adult emergence, 2) proper care of eucalyptus trees by watering and thinning stands, and 3) the utilization of resistant species such as *E. cladocalyx*. Identification of the attractive volatiles released by eucalyptus logs will allow us to develop a lure or trap that may be useful in monitoring or even controlling eucalyptus longhorned borer populations.

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