FLATHEADED BORER IN WHITE ALDER LANDSCAPE TREES

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Abstract. Flight of a flatheaded borer (*Agrilus burkei*) begins in late March or the beginning of April and lasts for 35 to 62 days. After emergence through D-shaped holes in the bark, the adults feed for one week on the foliage; they live about 12 days. The first egg mass is oviposited 7 days after emergence. Hatched larvae penetrate the bark surface directly into the phloem tissues. The larval stage lasts from April to February of the next year. In March a pupa is formed beneath the bark and the new imago emerges. The apparent propensity of A. bur*kei* to attack poorly growing alder trees suggests that white alders, *Alnus rhombifolia*, should be planted only in landscapes where moisture stress can be avoided or minimized.

Agrilus burkei, a flatheaded borer, is native to most of North America west of the Rocky Mountains (5). The borer attacks white alder, *Alnus rhombifolia,* a California native tree that occurs along the banks of permanent streams. Over the past several decades, about 30,000 nursery-produced white alders have been planted annually in California landscapes, many of which are unlike those where the tree occurs naturally.

White alder losses due to borer attacks have reached 30 to 40 percent within two growing seasons after planting. Selective infestation of stressed trees is prevalent among members of the beetle family Buprestidae to which *A. burkei* belongs (4,5,6,9). This insect probably dispersed from naturally occurring alders to planted, landscape trees and thereafter among planted alders. In a few cases investigated, specimens of this insect are known to have been moved long distances in infested nursery stock (Fig.1A,1B).

Owing to the severity of infestations of *A. burkei* in California landscapes from Lake to Monterey counties and to lack of information about the beetle's life history, we began experiments in 1985 to study aspects of this insect's life history and infestation characteristics that might be useful in developing cultural and chemical control procedures.

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Methods

Life history. In the early spring of both 1986 and 1987, a heavily infested white alder was chosen in Walnut Creek for monthly observations of *A. burkei* larval, pupal and imago development. The bark of 100 cm^2 surface areas was removed with a chisel and the presence of larva, pupa or imago was recorded.

Six bolts, 0.5 m in length, were cut from three infested trees in mid-March 1986 and 1987, and

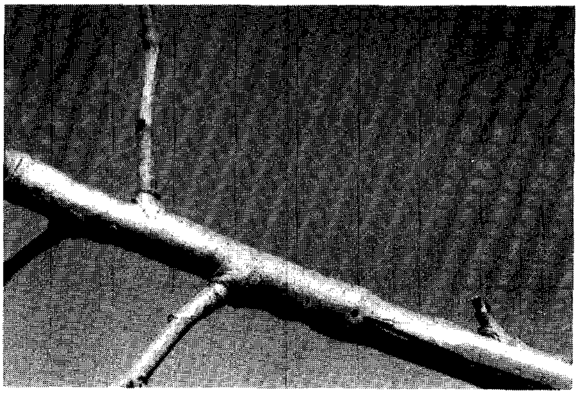

Figure 1A. Infested branch of white alder. The tree was delivered from the nursery in a 25 gal container.

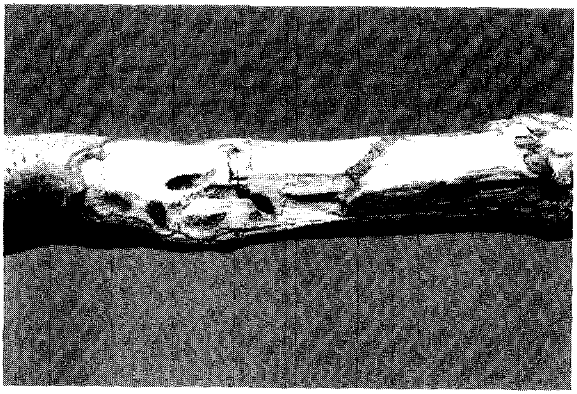

Figure 1B. The same branch cut open. The larva was boring into the wood causing swelling but no bleeding.

three of each were placed in two ventilated rearing containers with a collection jar at the bottom of each. The rearing containers were held outdoors in the shade in Lafayette. Beetles collected in the jars were counted daily to determine the beginning and termination of emergence, and then correlated with day-degree accumulations. Degree-days were calculated, beginning 1 January, using 11°C as the base temperature (8). The daily maximum and minimum temperatures were recorded at a University of California IPM Weather Station in Antioch, about 8 miles from Lafayette and Walnut Creek.

In 1986 and 1987 emergence was also monitored on three living infested trees in Walnut Creek. On each tree, the surface of a 0.5 m long infested limb or upper trunk section was checked daily for exit holes beginning in mid March. New beetle exit holes were marked, to prevent recounting, and recorded daily (Fig.2). After the first exit hole appeared, we climbed into its canopy every day until we detected the first egg mass.

Groups of 14, 16, and 18 of the newly emerged beetles from the rearing containers were released into ventilated cylindrical cages (25 cm in diameter and 50 cm tall) containing five 15-cm-long, freshly cut alder twigs with foliage. The cut end of each twig was driven through a pre-formed hole in a rubber plug tightly fitting into a vial with water. We replaced the cut twigs and water daily and at the same time checked for beetle mortality, feeding, and egg masses. The cages were held in the shade outdoors in Lafayette.

Tree infestation characteristics. In 1985 and 1986, two established landscape plantings (12 and 16 years old) of white alders in Moraga, with 13 and 9 trees respectively, were studied to determine the relationship between tree diameter (measured in cm, 0.75 m above ground) and degree of infestation or injury by the borer. Degree of tree infestation was visually assessed by numerically rating the extent of the tree's total bark surface stained by sap exudation resulting from larval feeding beneath the bark. Extent of tree injury was estimated in the fall by a numerical rating of canopy killing (Following column).

An 8-year-old landscape planting of 15 trees in Walnut Creek was used in 1986 to study the relationship between the extent of tree injury and

Degree of Infestation and extent		Degree of Injury and extent	
1	No stain	1	No dieback
2	Up to 10% of bark	2	Flagging on individual stained top branches
3	20 to 30% of bark	3	30% of top branches stained killed
4	40 to 50% of bark	4	50 to 75% of branches stained killed
5	Major limbs are killed - heavy staining only at the junction of major limbs and the trunk	5	major limbs are dead - dead tree

the number of egg masses deposited by *A. burkei*. Extent of injury was estimated by the canopy rating system described above. Counts of egg masses were made June 12 by searching the trunk and scaffold limbs of each tree for two 1-minute periods.

In January 1986, a planting of 30 randomly chosen 2-year-old white alders was established, 5 m apart in three rows 5 m apart, at the Deciduous Fruit Field Station, Santa Clara. When planted from bare root stock, each tree was approximately 2 cm in diameter at 0.75 m above ground level; tree trunk diameters were measured periodically thereafter. All tree rows received similar furrow irrigation semimonthly during the ensuing growing seasons. Just before the expected beginning of adult beetle emergence in 1988, 24 bolts of infested alders (each 0.5 to 0.75 m long) cut in Contra Costa County, were placed in that planting in four piles. Each of the 30 trees was searched for egg masses for one 45-second period on 19 May 1988. The diameter of each tree at planting was then subtracted from that at the time of the egg mass search. The median trunk diameter increase of the 30 trees was used as a basis to divide them into two size groups. The mean numbers of egg masses counted on the two groups were compared.

Results and Discussion

Life history. In 1986 beetles began to emerge in late March and continued throughout April and May (62 days). Considerable departures from this pattern were noted in 1987, undoubtedly due to seasonal temperature differences. Emergence began in the second week of April and lasted only 35 days (Fig. 3).

The calculation of accumulated degree-days from January 1 to March 30 in 1986 showed that beetles required a total of 653 degree-days to begin emergence, while in 1987 only 630 were needed (data from IMPACT Weather Stations Service, University of California, Davis). The 1987 winter-spring period was colder than in 1986, and the beetles therefore remained a longer time beneath the bark.

The 1987 emergence period of 35 days ended on May 15 (Fig. 3), when 1,160 degree-days had accumulated since January 1. The 1986 closest value of 1,169 required 49 days and the flight still had not terminated. Thus, the 1986 flight period was much cooler than that in 1987, which is the reason beetles continued to emerge from trees and cut bolts for 58 to 62 days in 1986. Although selection of 1 January as the starting date was arbitrary, observations suggest that if more data were collected, spring emergence could be predicted by using day-degree accumulations to formulate a pest control strategy.

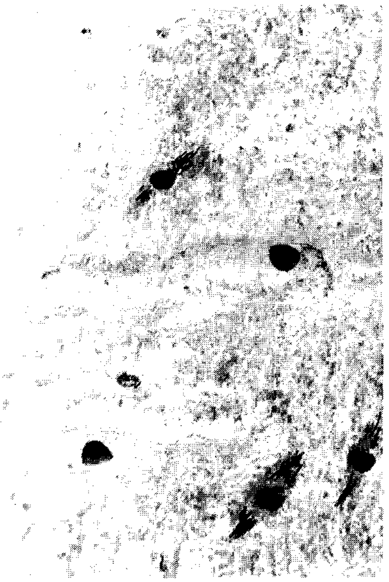

Figure 2. The D-shaped exit holes of *A. burkei* on the bark surface of white alder monitored for emergence. The holes marked with the pencil had appeared in previous days.

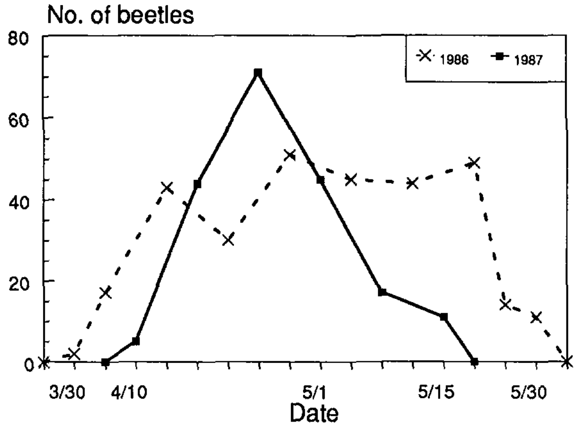

Figure 3. Emergence of *A. burkei* adults from infested bolts cut just before emergence and held outdoors.

The emergence pattern recorded from rearing containers was almost identical with that from naturally infested limbs and trunks, except that the first adult chewed through the bark (Fig. 2) two days later in 1986 and beetles continued to emerge for 58 days. In contrast, the 1987 emergence in both the rearing containers and infested trees began on the same day but terminated on infested trees four days before the last beetle was collected from the containers.

Once adults exited from the bark, they briefly gyrated on the bark surface around the hole and then crawled speedily upward about a foot (0.3 m), from where most flew off; the rest continued crawling to the foliage. Beetles fed on the margins and inner parts of white alder leaf blades. Aggregation of adults on the foliage of heavily infested trees occurred regularly on the southwest side in the late afternoon when active feeding and mating was observed (Fig.4). Preference for the sunny side of the host has been reported for other buprestids (4,7).

After mating, females laid prominent circular, whitish egg masses, 3 to nearly 5 mm in diameter, on the bark of trunks and branches of selected alder trees (Fig. 5). Neither in the field nor in rearing cages did we find egg masses less than 7 days after first adult emergence. Forty-eight adults caged with alder twigs and foliage lived an average of 11.9 ± 0.8 days.

Observations on infested trees from which bark

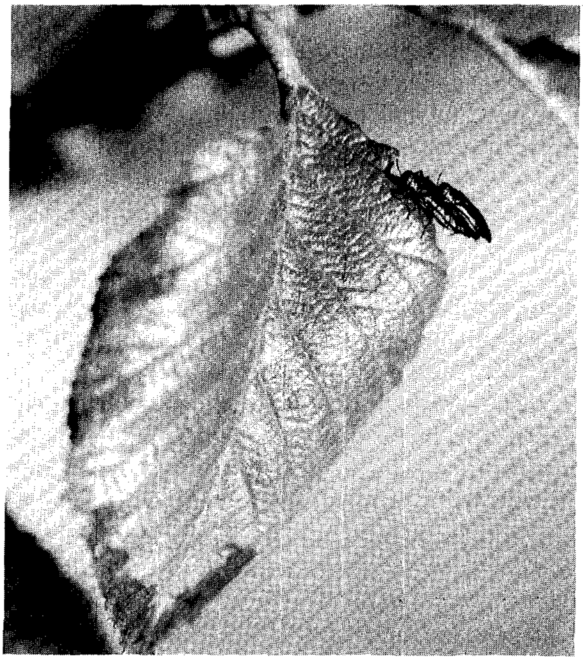

Figure 4. Female feeding on the leaf margin while mating.

Figure 5. Whitish to light yellow egg masses appear on the woody parts in April and May. There is no apparent pattern where egg masses are oviposited, except for a higher density near the stain boundary.

was removed monthly during 1986 and 1987 confirmed that *A. burkei* larvae hatched under the protective crust of the egg mass and then penetrated directly through the bark below, initiating winding galleries in the phloem tissues (Fig.6). As galleries expanded, the xylem tissue was also scored, and infested alder trees quickly produced copious amounts of sap which resulted in staining and discoloration of the exterior surface of the bark. In many trees, callus growth beneath the bark later caused prominent ridges and swellings. In some cases callus growth appeared to have crushed and killed a high proportion of the invading larvae. The bark removed from heavily stained trunk or limb sections contained very high densities of larvae, which had caused complete girdling of phloem-xylem tissues, top branch dieback, and frequently death of the entire limb or tree. Some alders were killed within a single year, but most required 3 or more years of infestation before succumbing. Similar observations of the dieback induced by high larval density have been reported for other buprestids (1).

The larval stage of *A. berkei* was observed from April until February of the following year. Pupation then occurred in a slightly enlarged chamber at the end of the larval gallery. There was only one generation each year, since no stage except young larvae was ever found when trees were opened just after adult emergence had ceased.

Beetle oviposition rate on previously infested trees. Females discriminated in their choice of trees for egg-laying, as has been suggested for several other buprestids (1,2,3). Most egg masses were deposited on trees moderately to rather severely injured by previous generations of borer larvae (Fig. 7); of 949 egg masses counted on a planting of 15 landscape white alder trees in Walnut Creek in June 1986, only eight (less than 1%) were found on a tree with no injury and only 22 (slightly more than 2%) on two trees nearly dead. Thus, females oviposited 93% of their egg masses on trees displaying bleeding caused by larval tunneling in the previous year. Barter (4) reports that climbing spur injuries to birch trunks attracted *A. anxius*.

Oviposition rate on alders free of borer infestation. In May 1988, we counted 168 egg masses on trees in the experimental planting established at Santa Clara. Significantly more ($P \geq 0.05$) were found on trees that had increased

Figure 6. Tunnelling of larvae at its initial stage. Larvae score xylem-phloem tissues, but do not bore into the wood in larger diameters.

the least in trunk diameter since their planting 2.5 years earlier (Fig. 8). Although all alders at the Santa Clara location had received the same care, some grew much faster than others; probably in response to a better root environment. Female beetles apparently were attracted for oviposition to the trees with poor growth.

Evaluating the egg mass distribution in two different stands (the first one previously attacked by *A. burkei* and declining due to subsequent larval boring in the past years, and the second one free of attack until the first adults were released), it appears that *A. burkei* females were capable of distinguishing susceptible trees from non-susceptible ones. We counted 152 egg masses on

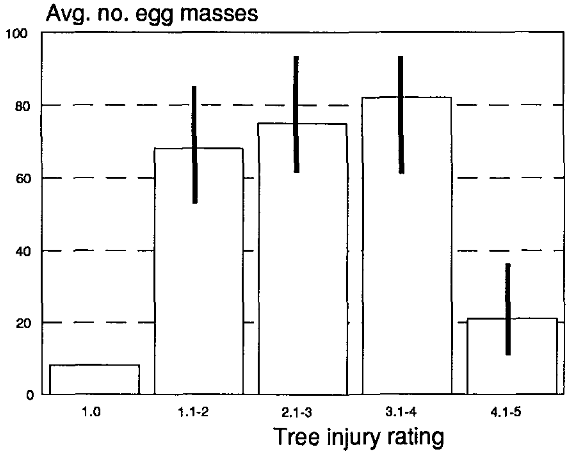

Figure 7. Number of egg masses (mean± SE) found on trees of varying degrees of injury by *A. burkei.* 1=low injury, 5=high injury, thick bar indicates SE.

trees with a poor growth rate, but only 16 on the same number of vigorous trees (measured by tree trunk diameter as a physical characteristic). There are undoubtedly numerous other variables affecting host attraction and egg mass concentration on suitable trees that have not been measured. Copiously bleeding injuries due to larval tunneling in previous year(s) certainly contributed to the release of host volatiles that probably increased dramatically the attractiveness of the host and concentration of egg masses on such trees (Fig. 7).

Concentration of attacks on declining trees. In two isolated landscape plantings of white alder in Moraga, significant (P≥0.05) linear regressions of degree of infestation (stained bark) and of amount of insect-caused damage (canopy dead) on tree diameter were found (Fig. 9,10). Trees of the same age but growing faster with a larger trunk diameter sustained less infestation or resultant branch death than trees of the same age with a smaller diameter. Of course, it must be remembered that *R* values are relatively small. Physiological and growth responses of white alders greatly vary in landscape conditions. We could not locate a larger and uniform sample size to demonstrate this relationship. These results are consis-

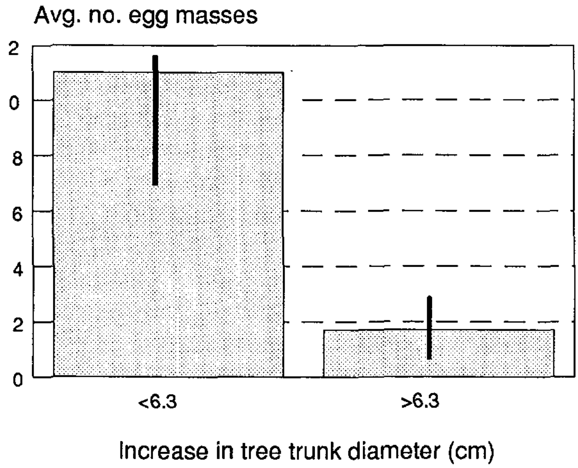

Figure 8. Number of egg masses (mean ± SE) found on 15 alders that had increased in trunk diameter less than the median increase of 6.3 cm, compared with those found on 15 trees whose increase in trunk diameter exceeded that median. Student's t test (P≥0.05). (Thick bar indicates SE).