FINAL REPORT
WTFRC Project # CH-03-300 **WSU Project # 13C-3643-3387**

Project title: Bark beetles (shot hole borer) in pome and stone fruit

PI: Jay F. Brunner
Organization: WSU Tree Fruit Research and Extension Center
Address, phone, e-mail: 1100 N. Western Avenue, Wenatchee, WA 98801
(509) 663-8181 ext. 238; jfb@wsu.edu

Co-PI and affiliation: Tim Smith, Cooperative Extension, Chelan-Douglas County

Objectives:
1. Identify the bark beetle species attacking pome and stone fruit throughout the state.
2. Compare the seasonal life history of bark beetles with current information.
3. Develop methods of rearing bark beetles in the laboratory.
4. Examine methods of monitoring bark beetles.
5. Assess efficacy of new insecticides against bark beetles.

Significant findings:
- The dominant bark beetle found throughout the state was the shothole borer (SHB), *Scolytus rugulosus* Müller. An ambrosia beetle, the European shothole borer (AB) (*Xyleborus dispar* Fabricius) and/or the lesser shothole borer (*Xyleborus saxeseni* Ratzeburg), was present in high numbers at only one location, a cherry orchard that had been abandoned for several years. At many locations more than one species of scolytids was detected.
- The life histories as determined in 2003 indicated one prominent flight of SHB that peaked in June and possibly two flights of ambrosia beetle. These data were inconsistent with some of the reported literature. Beetles appear to live a long time or emerge from various hosts over a long time.
- Woodpiles of apple and cherry are the main sources of high beetle densities that cause injury to commercial orchards. Cherry trees are most heavily attacked, and severe injury can result to trees adjacent to woodpiles. Injury accumulation continued well after peak flight, with damage occurring through September.
- Traps can be useful in identifying peak activity periods, but it is not clear whether they would be useful in setting thresholds for treatments. Available attractants enhanced trap captures, but it seems likely that with some effort better attractants could be found.
- Laboratory rearing of multiple generations was not successful. Adult SHB survived a short time on an artificial diet, but no reproduction occurred. Adults were reared and collected in large numbers from infested wood in the laboratory. Rearing of beetles on cherry or apple wood should present no problems, but this takes a lot of space to rear numbers needed to conduct additional studies of development or pesticide screening.
- A preliminary protocol was developed for screening insecticides against SHB adults. The method seemed to work well when tested against older adults but needs to validated against reproductively active adults.

Methods:
Species identification:
Bark beetles were reared from infested stone and pome fruit. Infested fruitwood was collected from many SHB infested areas throughout central Washington. Care was taken to record the plant host and describe the galleries, as these can be important characteristics in identifying scolytids. Adult SHB

and associated natural enemies were collected from the infested wood by laboratory rearing in darkened cardboard cages having a vial to catch emerged beetles and parasitoids that fly toward the light. Adult beetles were preserved and identified using established keys. Samples were collected from spring through fall and from all locations of the state. Verification of the identifications will be done by submitting specimens to experts. In addition to beetles, the natural enemies collected from the beetles or emerging from galleries will be identified.

Life history/monitoring methods:
At selected locations, the seasonal life history (adult activity) was examined. Beetle emergence from wood was monitored by collecting infested wood and rearing SHB to the adult stage in a cage. Cages were examined at regular intervals and beetle adults collected. The beginning of new beetle egg-laying galleries was recorded and tagged. Any second-generation emergence was followed in these cages. The timing and longevity of adult beetle activity was compared to historical information on bark beetles.

There are established monitoring methods for bark beetles. These are generally associated with monitoring in forest systems but could have some potential for use in orchards. We monitored infested sites with yellow sticky traps (unbaited Pherocon AM Trap, Trécé, Inc.) along with commercially available interception traps (Pane Intercept Trap, IPM Technologies; 8-funnel Lindgren Funnel Trap, Phero Tech, Inc.). Several side-by-side comparisons were made with the available trapping systems to determine the most effective way of monitoring SHB infestations. All traps were placed when beetles began to emerge in the spring (April) and were checked at regular intervals throughout the season. The sites used for species identification described above were also used for monitoring studies.

Distribution of feeding damage from a source adjacent to a cherry orchard was monitored at one orchard with a particularly severe infestation. The situation was a burn pile started in the spring of 2003 next to a firewood pile that was added to annually. A five-year-old Rainier cherry orchard was planted adjacent to this source. The cherry orchard was narrow, only five rows deep. Ten trees from each row were sampled in September, and the percentage of shoots with visible signs of SHB adult feeding was recorded.

Laboratory rearing:
In order to make progress on the understanding of bark beetle control and biology it will be very helpful to establish a laboratory colony. This would allow for year-round research activity and the possibility of developing an insecticide screening method for beetles. Various sources of wood types and conditions will be used to initiate colonies. SHB adults were collected from infested wood as described in the *Species Identification* section. The majority of adults were collected following peak flight noted in June. Adults were exposed to both drying wood in a cage and cups of artificial scolytid diet (southern pine beetle diet # F9761B, Bio-Serv, Inc.). The rearing arenas were examined regularly for SHB feeding activity and any sign of reproduction.

Insecticide screening:
Adult SHB, presumably from the early summer flight, were collected from infested wood that was returned to the laboratory in August and September. The insecticide screening methodology was designed to analyze the efficacy of field-aged residues. Mature Delicious apple trees at WSU-TFREC were treated with recommended rates of various insecticides commonly used in apple and cherry production. An effort was made to screen candidate insecticides from as many classes of insecticides as possible. Treated apple branches were collected at 1, 7, 14 and 21 days after treatment (DAT) and returned to the laboratory. Approximately 6-inch sections of 1- to 2-year-old wood were added to 32

oz deli cups (Anchor Packaging, Inc.). Untreated apple branches were used as a control at each evaluation date. SHB adults were added to the deli cups, and survival was recorded at one day and three days. All of the chemicals screened were neuroactive insecticides with relatively quick modes of action. Therefore, consistent data were collected at the three-day evaluation, and it was not necessary to run the test for a longer time period. Five cups with five SHB adults were set up for each insecticide at each evaluation period (25 SHB adults/treatment).

Results and discussion:

Species identification:

Infested fruitwood was collected from 10 sites ranging from the Wenatchee valley to Oroville. Several hundred adult scolytids were collected and preserved for identification. At the time of this report, verification of our initial identifications has not been completed.

The dominant bark beetle found throughout the state was the shothole borer (SHB), *Scolytus rugulosus* Müller. An ambrosia beetle, the European shothole borer (AB) (*Xyleborus dispar* Fabricius) and/or the lesser shothole borer (*Xyleborus saxeseni* Ratzeburg), was present in high numbers at only one location, a cherry orchard that had been abandoned for several years. At many locations more than one species of scolytids was detected. Further, many other wood-decomposing beetles were reared from infested wood. In fact, the majority of beetles collected were associated with dry, dead wood. Buprestids, bostricids and powderpost beetles (Lyctidae) were the primary families of beetles associated with dry, dead wood. The SHB and AB appear to be the primary attackers of live and weakened trees. Initial observations at the time of collection show that there was fairly significant parasitism (up to 50%) of SHB larvae by hymenopteran parasitoids. These have been submitted for identification.

Life history/monitoring methods:

It was believed that AB overwinter as adults while SHB overwinter as mature larvae or pupae. Thus, it would be expected that AB adult flight would be detected first as temperatures warmed and the adults became active. This appeared to be the case in 2003, as AB adults were detected in the traps prior to SHB (Figure 1). AB activity began in early May and peaked in mid-May. A possible second flight was observed during July. The life histories as determined in 2003 indicated one prominent flight of SHB that peaked in June. Adult activity was noted with both species throughout the entire summer. These data were inconsistent with some of the reported literature for both species. It should be noted that our traps were not placed until the middle of April, and it is known that some scolytids, and possibly SHB, could be active during March. It is not known if this is the case in Washington, but initiating trapping earlier in 2004 should resolve that question. Beetles appear to live a long time or emerge from various hosts over a long time. The exact biology and life history of these insects is difficult to determine with one year's research. It is possible that a portion of the summer SHB larval population emerged during the late summer while the majority of larvae ceased development, remaining in a diapause-type condition. These individuals will likely overwinter and emerge next spring or early summer.

Woodpiles of apple and cherry are the main sources of high beetle densities that cause injury to commercial orchards. Cherry trees are most heavily attacked, and severe injury can occur to trees closest to woodpiles (Figure 2). Injury appeared to be closely associated with the population source and extended only a short distance into an orchard. Younger trees were more susceptible to severe injury, as high numbers of attacks to a young tree would be more damaging. Injury accumulations from SHB, as noted by adult feeding at the base of buds, began during the peak flight in June and continued through September.

Traps were useful in identifying peak beetle activity periods, but it was not clear whether they would be useful in setting thresholds for treatments (Figure 3). There did not appear to be any significant difference in commercially available trap types. Either the Pane Intercept trap (IPM Tech, Inc.) or the Lindgren Funnel Trap (Phero Tech, Inc.) was a suitable trapping system to monitor both SHB and AB adult activity. Available ethanol attractants enhanced trap captures, but the lure system seemed to be a limiting factor in the monitoring system (Figure 4). It is likely that better attractants could be found.

Laboratory rearing:
Laboratory rearing of multiple generations was not successful. Adult SHB survived a short time on an artificial diet, but no reproduction occurred. Adults were collected and reared in large numbers from larval infested wood in the laboratory. Rearing of beetles on cherry or apple wood should present no problems, but it would take a lot of space to rear numbers needed to conduct additional studies of development or pesticide screening. An efficient means of rearing insects in the laboratory or under controlled environments would make precise observations of phenology possible.

Insecticide screening:
A preliminary protocol was developed for screening insecticides against SHB adults. The average survival of SHB adults introduced to rearing arenas with untreated sticks was above 80% through the three days of observation. This level of survival indicates that any significant mortality noted in the rearing arenas could be attributed to pesticide exposure and not a problem with the protocol. The method seemed to work well when tested against late summer adults but needs to be validated against reproductively active adults collected during peak flight.

Preliminary results indicate that the most active insecticide against SHB adults was the pyrethroid, esfenvalerate (Asana XL) (Table 1). It is likely that other products from this same class of insecticides would be active as well. There was some evidence that the organophosphate insecticides tested may not give the control that a grower would like. Survivors were detected at each bioassay interval with azinphos-methyl (Guthion). Malathion was very active early as one-day residues, but older residues showed reduced mortality. It appeared that the chloronicotinyls [acetamiprid (Assail) and thiamethoxam (Actara)], the carbamates [formetanate hydrochloride (Carzol) and carbaryl (Sevin)], endosulfan (Thiodan), indoxacarb (Avaunt), and spinosad (Success) were not highly effective as controls for SHB. However, significant mortality was noted with many of these products for up to seven days, and their repeated use during the growing season may be responsible for maintaining SHB and AB populations below damaging levels in most commercial orchards. Cherry orchards may become susceptible to injury in the postharvest period when insecticide programs for cherry fruit fly and leafroller have ceased.

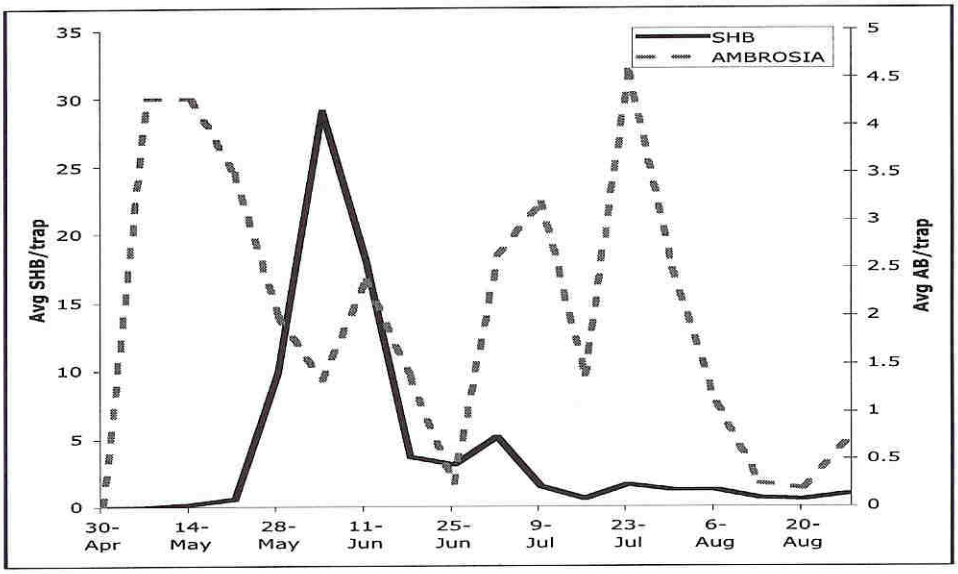

Figure 1: Average adult scolytid captures in ethanol-baited traps, 2003.

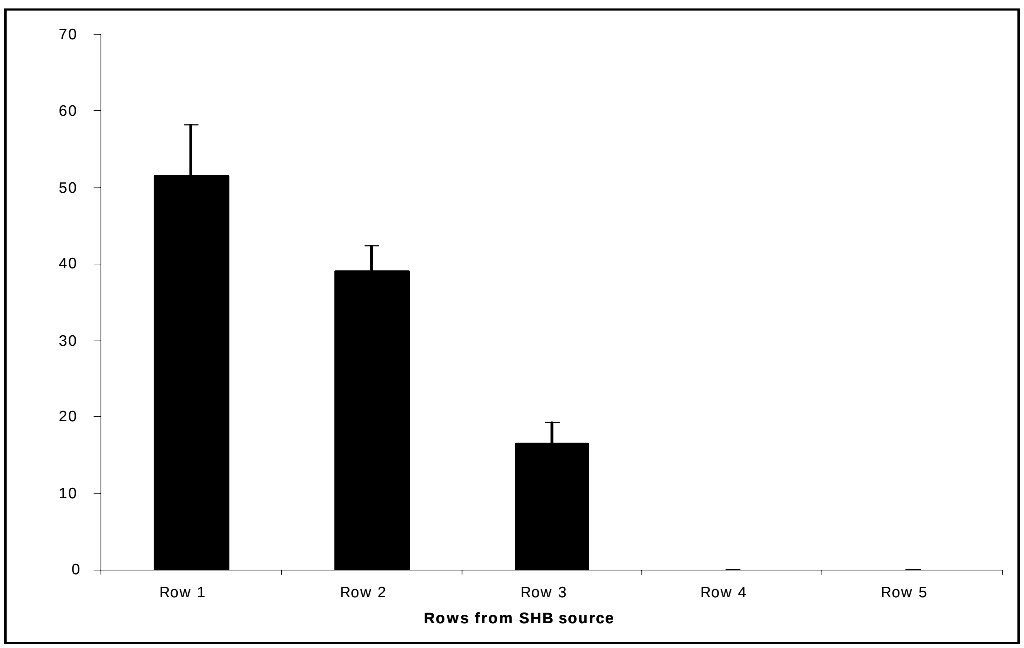

Figure 2: Distribution of adult SHB feeding damage by distance from a source adjacent to a cherry orchard, 2003.

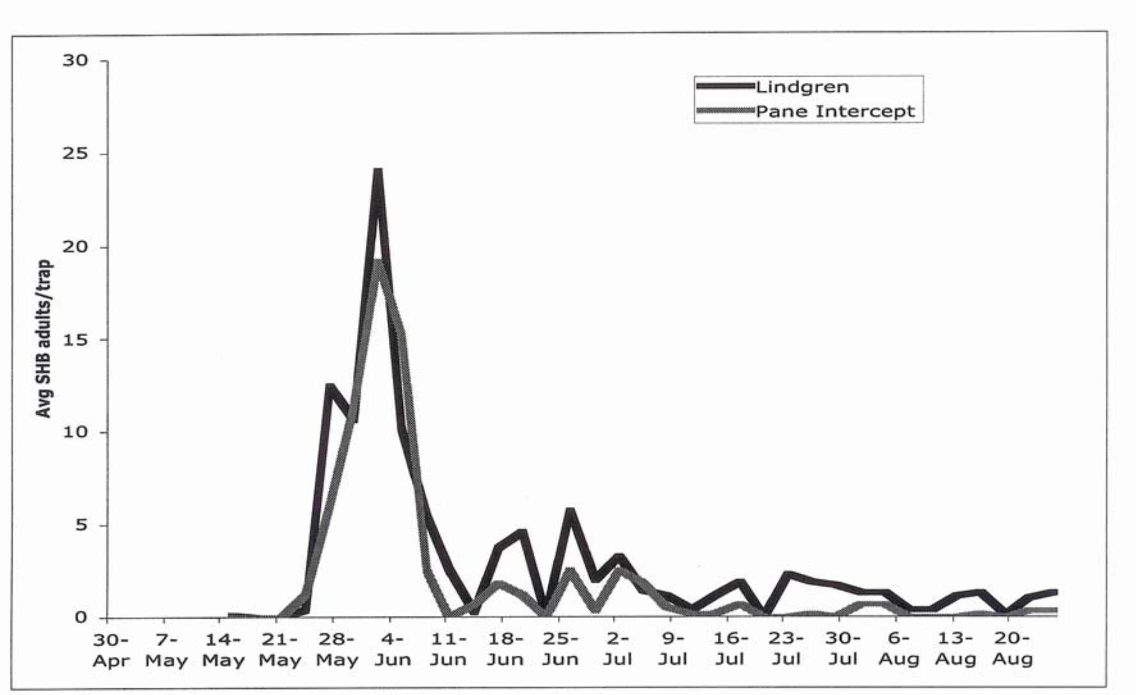

Figure 3: Adult SHB trap captures in commercially available scolytid traps, 2003.

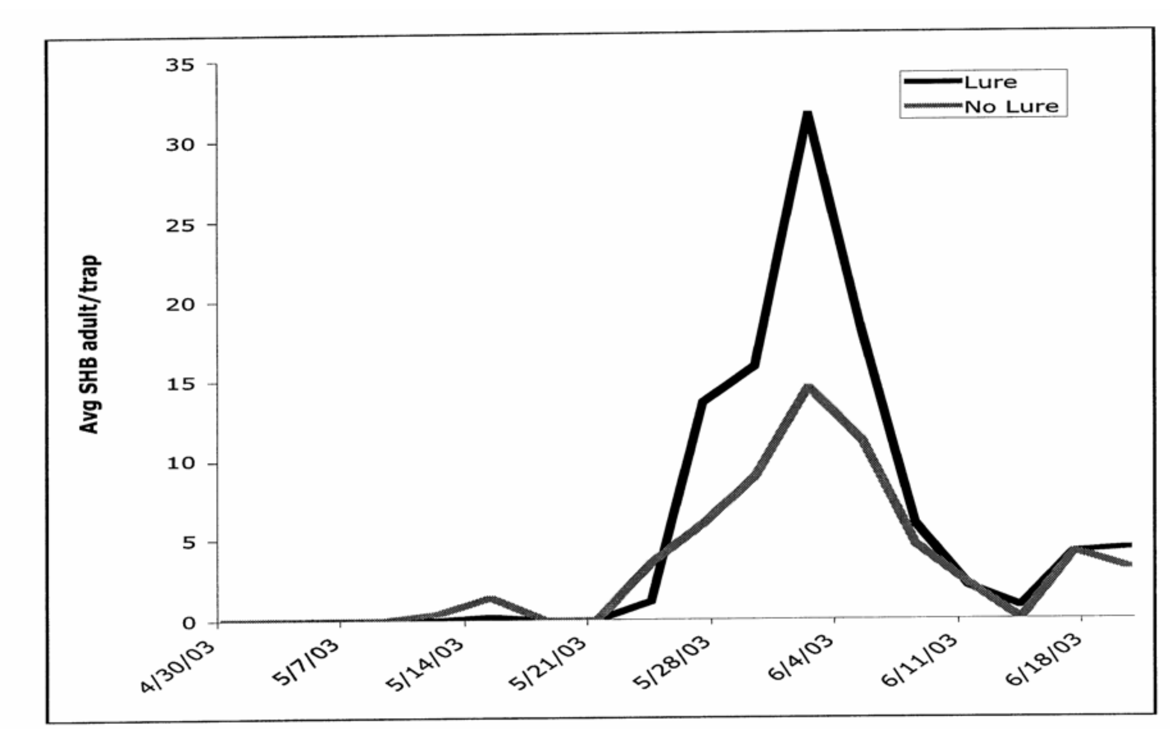

Figure 4: Relative effect of an ethanol lure on adult SHB trap captures, 2003.

Table 1: Relative effect of field-aged insecticide residues against SHB adults, September 2003.

Insecticide	Rate (form/a)	Avg corr % mort. (3-day evaluation) 1 DAT[1]	7 DAT	14 DAT	21 DAT
Guthion 50WP	2 lbs	87.5	75.0	25.0	75.0
Malathion 50%	1.5 qt	100.0			
Assail 70WP	3.4 oz	50.0	50.0	25.0	25.0
Actara 25WDG	4.5 oz	100.0			
Asana XL	8 fl oz	100.0	100.0	100.0	100.0
Thiodan 3E	3 qts	87.5	25.0	25.0	25.0
Carzol 92SP	1.25 lb	62.5			
Sevin XLR	1 qt	25.0			
Success 2SC	6 fl oz	87.2	62.5	75.0	0.0
Avaunt 30WDG	6 oz	75.0	12.5	0	50.0

Summary of total project costs:
Project duration: one year (2003)
Total project costs: $20,040