# THE SHIGOMETER AS PREDICTOR OF BRONZE BIRCH BORER RISK

by John J. Ball and Gary A. Simmons

**Abstract.** Experiments were conducted during 1981 to determine if borers concentrate their attack on certain trees and if the Shigometer might be used to separate these trees from the rest of the population. Twenty European white birch *(Betula pendula)* representing different stages of dieback were used. Pyrethrum was applied to the tree crowns on alternate days and the stunned adult bronze birch borers were collected. Emergence from each tree was also recorded. All trees exhibiting symptoms attracted adults and had emergence. Three trees that exhibited minor flagging or no symptoms also attracted adults to their crowns, but no emergence was observed. The Shigometer was a reliable measure of susceptibility to borer attack. All trees that were attacked gave readings in excess of 12 kohms, regardless of crown appearance.

Birch dieback is a serious problem of birch in the northern half of the United States. One study showed that over 40% of the European white birch *(Betula pendula)* in one midwestern city were exhibiting crown dieback (Ball and Simmons 1980). Birch dieback begins with the tree being altered by environmental stress (Balch and Prebble 1940). Once weakened, the birch is attacked by the bronze birch borer *(Agrilus anxius)* and usually dies within several years (Barter 1957).

The bronze birch borer is a phloem feeder during the larval stage. Larvae usually exist from July until May of the following year. The pupal stage begins in April or May and lasts approximately one month. In lower Michigan, adults begin emerging from D-shaped holes in early June; emergence continues for about six weeks (Wellso et al. 1976). Eggs are laid in bark crevices or under loose bark flakes. The eggs hatch in 14 days. The larva immediately burrows into the bark and proceeds to the phloem region. The borer generally has a one-year life cycle, but in parts of the northern United States and Canada a two-year life cycle is possible (Balch and Prebble 1940).

The bronze birch borer is only a contributing factor in the decline and death of the birch (Manion 1981). This does not imply that the borer has only a minor effect on the tree's health. The girdling created by the larvae as they tunnel through the phloem can seriously disrupt the flow of carbohydrates and hormones. If a large number of larvae are tunneling through the phloem, girdling will hasten the death of the already stressed tree.

Urban management of birch dieback currently consists of early summer application of a pesticide to reduce the population of emerging adult bronze birch borers. But do all birch trees need to be sprayed? We believe that only certain trees have been sufficiently stressed to be vulnerable to attack. During the past several years, we have observed that birch dieback is a progressive process, and we have developed a crown vigor classification system to better illustrate this progression (Table 1) (Ball and Simmons 1980). A tree may alternate between class 1 and 2 for many years. During these years the tree will be free of borers. Then, within a year, the tree will decline to a class 3. Class 3, 4 and 5 trees are borer infested. Apparently class 1 or 2 trees undergo some physiological change making them vulnerable to attack. If this hypothesis is correct, it might prove beneficial to monitor tree condition and to single out trees most vulnerable to attack. These trees could be given pesticide applications along with additional measures to reduce stress. Hence the purpose of this investigation was to test whether borers selected certain trees for attack. If attack was concentrated on certain trees, we were interested in finding if these trees could be separated from the remaining population by differences in their stem electrical resistance.

## Methods

Experiments were conducted in a four-acre abandoned tree nursery near Richland, Michigan, consisting of approximately 60 European white birch trees. Twenty 10- to 15-year-old trees, 3.6 to 9.4 cm dbh were randomly selected, five each representing classes 1 through 4.

To estimate the adult borer population on these trees, a chemical knockdown agent, pyrethrum (Dill's Pyrethrim EMS) was used (Collyer 1951). The spray dilution, 3.0 ml pyrethrum/1.0 L water, was sufficient to remove adults from the canopy. The twenty trees were sprayed between 11:00 a.m. and 3:00 p.m. on alternate days between June 1 and July 15, 1981. After spraying, adults were collected from a white tarp wrapped around the base. At the conclusion of each spray day, each tree was examined for new emergence holes. The number of new holes was counted, and the holes were filled with caulking compound.

All 20 trees were felled and the bark removed between May 20 and May 30, 1982. Once the bark was removed, all larvae and pupae were counted. The trees were also cross-sectioned at 50 cm intervals to detect galleries from previously successful attacks by the borer.

Stem electrical resistance was measured on June 1 and July 1, 1981. The resistance was measured with the Shigometer model 7950, with a 50 kohm scale. The Shigometer produces a pulsed current of 0.5 ms with a 10 ms interval between pulses (Skutt et al. 1972). The meter was attached to a plastic handle containing two 1 cm uninsulated stainless steel needle electrodes. The two needle electrodes were inserted into the trunk bark at 1.37 m above the ground until deeper manual insertion became difficult. Line of sight between the electrodes was vertical, paralleling the long axis of the tree trunk. Measurements were taken on both the north and south sides of the tree. The two readings were averaged for the analysis. All electrical resistance measurements were analyzed with diameter as the covariant as several past studies have noted that electrical resistance was correlated with tree diameter (Wargo and Skutt 1975; Newbanks and Tattar 1977).

## Results and Discussion

Adult emergence from the 20 birch trees began on June 1 and continued until June 19, 1981. Only class 3 and 4 trees had adults emerge from them. Adult borers were collected from the tree crowns between June 1 and July 12, 1981. All class 3 and 4 trees produced adults, along with several class 1 and 2 trees (Table 2). For every tree more adults were collected than emerged. Two hundred and nine adult bronze birch borers were collected; 63% were female. This percentage is higher than reported by Barter (1957), who observed almost a 1:1 ratio. The higher percentage of female beetles can probably be attributed to the spray applications being applied at midday; according to Barter (1957) more female beetles are present on birch trees during midday.

The following spring these trees were examined for larvae and pupae (Table 3). These same trees had adults collected form them the previous summer, hence larvae and pupae densities were lower than found in our previous study (Ball and Sim-

**Table 1. European white birch crown vigor classification.**

| *Class* | *Criteria* |
|---|---|
| 1 | A full crown. |
| 2 | Scattered flagging at top of crown. |
| 3 | Upper crown twig and small branch dieback. |
| 4 | Dieback of at least 1 m in several branches. |
| 5 | More than one-half of the crown devoid of foliage, but still having at least several branches with foliage. |

**Table 2. Average number (± SE) of *Agrilus anxius* collected July 1-July 12, 1981 at Richland, Michigan from the crowns of Betula pendula representing four different crown classes (n = 5).**

| *Class* | *Total number of adults collected* | *Average number of adults collected per $M^3$ of crown* |
|---|---|---|
| 1 | 15 | 1.0 ± 0.8 |
| 2 | 2 | 0.1 ± 0.1 |
| 3 | 94 | 2.1 ± 0.5 |
| 4 | 98 | 4.5 ± 0.8 |

**Table 3. Average number (± SE) of *Agrilus anxius* larvae and pupae per 100 $cm^2$ of *Betula pendula* stem inner bark. Data collected May 20-30, 1982 in Richland, Michigan (n = 5).**

| *Class* | *Area of inner bark surveyed ($cm^2$)* | *Average number of larvae and pupae* |
|---|---|---|
| 1 | 40,480 | 0.05 ± 0.02 |
| 2 | 37,090 | 0.01 ± 0.01 |
| 3 | 43,595 | 0.35 ± 0.05 |
| 4 | 16,770 | 0.49 ± 0.08 |

mons 1980). However, there was a significant (P 0.05) positive correlation between adults collected in the summer of 1981 and the larvae and pupae density in the spring of 1982.

All class 3 and 4 trees contained larvae and pupae and had numerous old galleries, proof they had been attacked for several years. Larvae and pupae were also discovered in two class 1 trees and a single class 2 tree. They were the same trees that adults were collected from the previous summer. These three trees were examined for signs of past borer attacks, but none was found. Apparently this year was the first time the trees were successfully attacked.

We found a significant (P 0.05) positive correlation between adults collected and Shigometer readings. All class 3 and 4 trees had Shigometer readings of 12 kohms or higher. The three class 1 and 2 trees that had adults collected from their crowns also had Shigometer readings in excess of 12 kohms. Apparently these three trees were stressed, as shown by the high Shigometer readings, and the borers were able to identify these trees and successfully attack them.

## How To Apply These Results

There is some discussion on how a Shigometer should be used to determine relative tree vigor. Weather conditions may affect readings, therefore only electrical resistance readings taken on the same day should be compared (Shortle et al. 1977). We believe the Shigometer can be a useful tool in monitoring tree health; however, our value of 12 kohms should not be taken as an absolute. Arborists should measure a number of birch in each vigor class during the end of May. Next, compute an average for the low-vigor trees (class 3 through 5) and high-vigor trees (class 1 and 2). Any class 3, 4 and 5 trees should be considered high risk for borer attack, but also high risk are any class 1 or 2 trees whose readings are close to the average for the low-vigor trees.

## Summary

The bronze birch borer does not attack trees at random but instead selects certain trees for attack. While many of these selected trees are already exhibiting dieback symptoms, others may appear healthy. The most difficult task in birch dieback management is determining which of the apparently healthy trees are soon to be afflicted with dieback. The Shigometer, a portable device that measures electrical resistance, is one way to identify suitable hosts. Trees with a high stem electrical resistance generally are successfully attacked by the bronze birch borer. Birch dieback management should include monitoring and preventative care as part of the overall strategy. Class 1 or 2 trees that have a high stem electrical resistance reading should be considered stressed and vulnerable to bronze birch borer attack.

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*Assistant Professor, Horticultural Technology Department, University of Minnesota Technical College-Waseca, Waseca, Minnesota 56093 and Associate Professor, Department of Entomology, Michigan State University, East Lansing, Michigan 48824*