Population Levels and Sampling Methods for Red Oak Borer *Enaphalodes rufulus* (Haldeman) (Coleoptera: Cerambycidae)

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Introduction

Ozark forests of Arkansas, Oklahoma and Missouri are experiencing a widespread oak decline event in which red oak borer *Enaphalodes rufulus* (Haldeman) is implicated as a major contributing factor, Figure 1. Red oak borer is a native wood-boring long-horned beetle normally found at low population levels and has never been indicted as a causative organism in other oak decline events. Objectives of this research were to develop sampling methods based on the red oak borer's unique synchronous two-year life cycle to quantify within-tree red oak borer populations and to present preliminary population data.

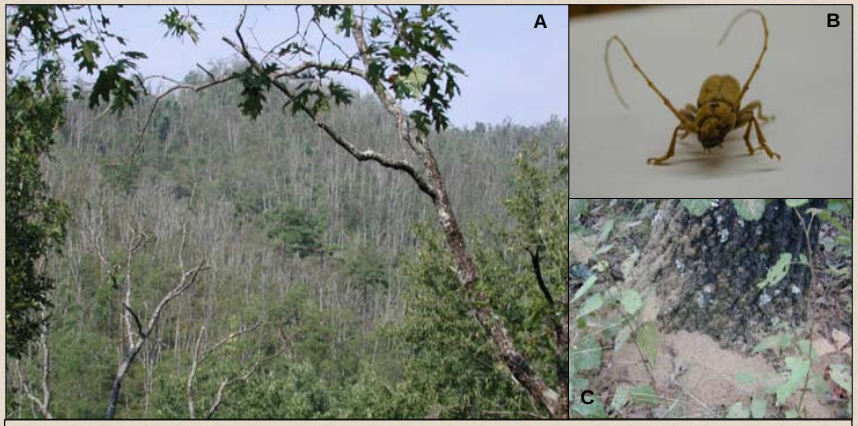

Figure 1. An oak decline event occurring in the Ozark National Forest (A) is coinciding with increased populations of red oak borer (B) as evidenced by frass accumulation at the base of infested trees (C).

Methods

Sixty-nine northern red oaks *Quercus rubra*, L. were harvested from 3 areas in the Ozark National forest of northern Arkansas between January 2002 and June 2003. Twenty-four trees were intensively sampled and provided whole-tree data for five red oak borer population variables, attack holes, current generation galleries, live larvae, emergence holes and previous generation galleries, Figure 2. This whole-tree baseline data was essential for development of subsequent sampling methods.

An extensive 9-sample proportional data set was derived based on intensive data and compared to real data using paired t-tests. Forty-five additional trees were then extensively sampled and extrapolated to tree level using whole tree surface areas.

A rapid estimation procedure (REP) using two variables, crown condition and basal emergence holes, was utilized for all sampled trees and facilitated classification into three infestation history classes. Class I trees appeared healthy with low infestation histories. Class II exhibited crown dieback and a moderate infestation history. Class III had high infestation histories and death was imminent.

Figure 2. Intensive tree dissection methods: Felling trees, mapping the bark surface for attack and emergence holes, bark removal to reveal live red oak borers as well as current and previous generation galleries, and splitting for live borers in heartwood galleries.

Results and Discussion

Population levels of red oak borer are orders of magnitude higher than any previously reported in the literature (Table 1). Donley and Rast (1984) found <4 attacks/tree in IN and PN while Hay (1974) found 2.9 active attacks on the basal 1.8 m of red oak trees in OH. Our current generation gallery numbers of 599/tree and 30/tree on the basal 1.5 meters are much higher.

Intensive sampling provides accurate data which can serve as a baseline for developing less time-consuming and expensive sampling methods. Extensive sampling takes only a fraction of the time compared to intensive sampling, mean percent bias was <6% for all measured variables, indicating that extensive sampling was acceptably accurate for the population variables measured (Table 2) Paired t-tests also indicate no significant difference between these methods. Use of this technique permits a greater sampling effort and with little additional effort, data can be extrapolated to the whole tree. Data derived from both intensive and extensive sampling are vital for determining within-tree populations as well as mortality analysis and life table development.

There were significant differences in population variables between REP classes (Table 3). From our data, it appears that red oak borer is a major causative agent in oak mortality as Class III trees (whose death was imminent) have had significantly more red oak borer complete their life cycle in them. Discriminant analysis revealed that field evaluation of REP variables permit reliable groupings for infested trees (Figure 3). The most beneficial aspect of the REP is that it can be evaluated in less than 2 minutes. This method then yields acceptably accurate population numbers which can be used to estimate population levels at tree, stand and landscape levels. These data can also be used in evaluation of forest health and in building predictive models for where and perhaps even when outbreaks may occur.

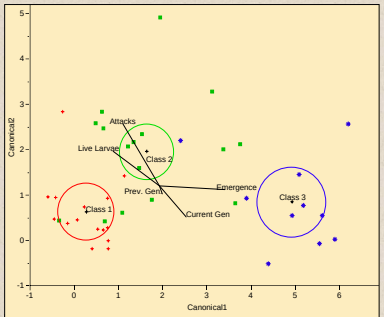

Figure 3. Discriminant analysis of REP classifications.

	Attacks	Current Generation Galleries	Live Larvae	Emergence Holes	Previous Generation Galleries
Mean	2,249 ±177	599 ±50	77 ±15	173 ±18	185 ±30
n	47	38	57	58	38

Table 1. Mean within-tree red oak borer population variables from trees harvested in the Ozark National Forest of northern Arkansas.

	Attacks	Current Generation Galleries	Live Larvae	Emergence Holes	Previous Generation Galleries
Intensive Mean	160.4	55.5	10.0	12.5	16.7
Extensive Mean	168.3	54.1	9.2	12.4	16.3
% Bias	4.0	-3.0	-4.4	-5.2	-1.9
df	12	7	22	23	8
P-value	0.1128	0.5299	0.1378	0.9528	0.5067

Table 2. Comparison of intensive and extensive density (per m^2) data. Mean percent bias quantifies how much extensive sampling over- or under-estimates intensive data. Paired t-tests revealed no significant difference between sampling methods for any of the population variables measured.

	Attacks	Current Generation Galleries	Live Larvae	Emergence Holes	Previous Generation Galleries
Class I	1,487 ±223 A	419 ±74 A	35 ±19 A	57 ±17 A	22 ±33 A
Class II	2,564 ±261 B	698 ±74 B	116 ±21 B	153 ±20 B	166 ±32 B
Class III	2,549 ±316 B	610 ±93 AB	52 ±26 AB	307 ±23 C	370 ±38 C
df	57	41	67	68	41
P-value	0.0033	.0336	0.0191	<0.0001	<0.0001

Table 3. Comparison of population variable means for REP infestation history classes. Standard error is given and different letters indicate significant differences at α0.05 using Tukey-Kramer means comparison.

References

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