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Emerald Ash Borer attacks trees revealing early chemical clues

The Emerald Ash Borer (EAB), *Agrilus planipennis*, is a major global forest pest (a buprestid beetle) that has decimated ash trees (*Fraxinus* species) throughout Europe and Asia. Since this nonnative invasive insect was introduced into the U.S. in the early 1990s (near Detroit Michigan), it has spread rapidly to at least 35 US states and five Canadian provinces, killing billions of ash trees in North America over the past 30 years. The small green-metallic adult females lay eggs in bark crevices which hatch to produce larvae that penetrate into the phloem and outermost rings of the sapwood to create extensive galleries (borer canals) as they feed. These galleries block the flow of vital carbohydrates and nutrients to the roots which slowly weakens the tree, causing gradual defoliation and ultimately death.

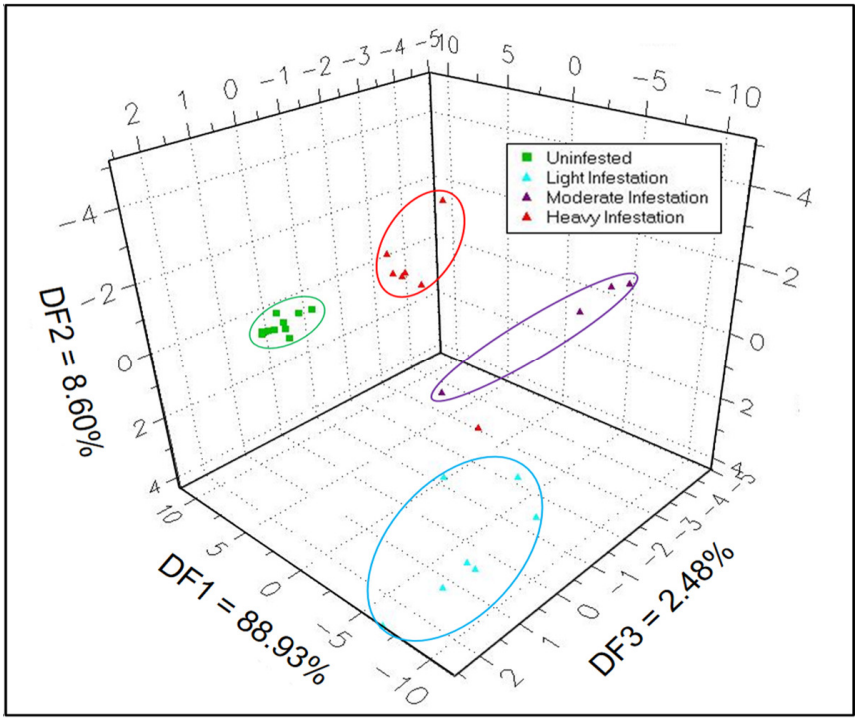

Fig. 1. Discriminate factor analysis aroma plot of four EAB-infestation levels.

Early infestations begin in the upper tree trunks and are not obvious because it takes up to a year or more before symptoms start appearing and the characteristic D-shaped adult emergence holes are visible. Consequently, control treatments cannot be applied early enough before substantial damage to trees has already occurred. The search for new methods to detect EAB infestations of ash trees at early stages, before visible indicators appear, led to the present discovery that larval feeding disrupts normal metabolic pathways of living tissues and cause the release of abnormal volatile organic compound (VOC) emissions, providing early chemical indicators of infestations. Effects of EAB-infestations on host metabolic processes, associated with levels of tissue damage by gallery formation and symptom severity, were shown from analyses of VOC emissions from sapwood cores taken from green ash trees at four different levels of attack. The well-defined infestation levels were based on an increasing scale of visible tree damage, ranging from healthy (no damage),

to light, moderate and heavy infestations. Differences in chemical composition of VOC emissions from the four infestation levels were indicated by a discriminate factor analysis (DFA) aroma plot that showed data clustering into four distinct groups corresponding to the different levels of infestations (Fig. 1).

Efforts to more precisely analyze the composition of VOC emissions from healthy and EAB-infested ash trees were investigated using a dual-technology electronic-nose (e-nose) device that contains a multi-sensor array to measure the diversity of VOCs (chemical classes) present in sapwood emissions, and to identify individual VOCs using gas chromatography. The data output from the e-nose sensor array produced a bar graph with a particular smellprint pattern that was unique to each sample type. The smellprint pattern of healthy ash trees were significantly different from EAB-infested trees at all levels of infestation, including light infestations prior to symptoms development (Fig. 2). These results showed that EAB infestations drastically down-regulated the production of normal VOCs produced by healthy trees, causing greatly reduced quantities and diversities of VOCs even at early stages of infestations. This information provided the technological basis for an effective method to detection EAB attacks soon after penetration of the tree bark by larvae at early stages of gallery formation.

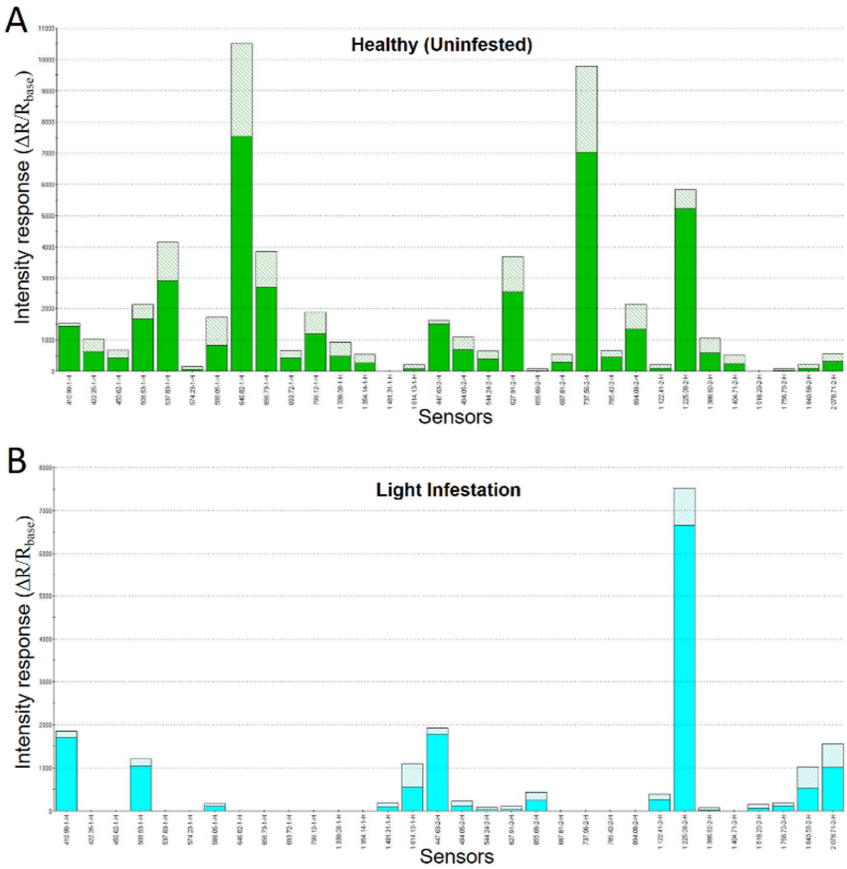

Fig. 2. E-nose smellprints of VOC emissions from sapwood cores of: (A) healthy ash trees, and (B) EAB-attacked ash trees with light infestations.

Several major applications are now possible from the use of e-nose technologies to measure VOC emissions in trees. Early detection of EAB infestations allow the application of control measures much earlier to help fight off attacks of healthy trees. Locating advancing fronts of EAB attacks of forests and its geographical movements will be useful in setting up regional quarantine regulations and high-hazard sites for pest suppression activities. The discovery of certain VOCs identified as 'healthy biomarkers' could be used to identify healthy trees, not requiring treatment, and as new possible sources of genetic resistance to this pest.

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Publication

Detection of Emerald Ash Borer infestations in living green ash by noninvasive electronic-nose analysis of wood volatiles
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