Using laser vibrometry to detect incidental vibrational signals

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Abstract

Bioacoustic approaches in detection of wood-boring insects exploit the sounds generated by larvae inside trees, cut wood and wood packaging material. The sounds are mostly a by-product of eating and locomotion. In our study, laser vibrometry was tested as a novel method to detect hidden insect infestations. The focus was on two invasive beetle species, the Asian Longhorn Beetle (Anoplophora glabripennis) and the Red Palm Weevil (Rhynchophorus ferrugineus).

Most bioacoustic sensors (microphones, accelerometers) require mounting to the measuring surface, which can be complicated, time consuming and may even damage the tested material. The laser vibrometer, on the other hand, offers possibility of a non-contact measurement of surface vibrations via the laser beam. This eliminates the mass loading of structures by conventional piezoelectric transducers. Other advantages of laser Doppler vibrometry are the broad frequency range (from 0 to 22 kHz), robustness and working distance up to several meters. Additional equipment needed for recording with the laser vibrometer (weight: 2.6 kg) includes a laptop, a tripod, and for outdoor recording a battery to power the vibrometer.

We used a portable digital laser vibrometer to detect larval activity within poplar logs and palm trees. Several types of vibratory signals were recorded in species of beetles, most very short in duration (1-6 ms), with frequencies between 2 and 20 kHz. The signal-to-noise ratio across the whole frequency range of the laser vibrometer (0-22 kHz) was around 35 dB. We showed that laser vibrometry can be successfully employed as a very sensitive non-destructive diagnostic tool for detecting infestations by the wood-boring beetles.
Detecting such vibrations can be widely used for detecting hidden organisms, in pest management, and potentially also for monitoring activities for ecological assessment.

Keywords: laser vibrometry, wood, boring insects, vibrations

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