The effect of pine weevils on VOC emissions from Scots pine saplings

E. Kari[1], C. Faiola[1], A. Buchholz[1], K. Kinnunen[1], A. Ayelotan[2], M. Kivimäenpää[2], P. Yli-Pirilä[1,2], J. K. Holopainen[2] and A. Virtanen[1]

[1]Department of Applied Physics, University of Eastern Finland, Kuopio, P.O. Box 1627 FI-70211, Finland
[2]Department of Environmental and Biological Sciences, University of Eastern Finland, Kuopio, P.O. Box 1627 FI-70211, Finland
Keywords: Biogenic volatile organic compounds, Plant emissions, Secondary organic aerosol.
Presenting author email: eetu.kari@uef.fi

A large variety of volatile organic compounds (VOCs) are emitted into the atmosphere by plants (Guenther *et al.*, 1995). The emission rates and chemical composition of VOCs released from vegetation are affected by biotic and abiotic stress factors (Holopainen and Gershenzon, 2010). One class of VOCs, called herbivore induced plant volatiles (HIPVs), are produced by plants in response to herbivory. One of the primary functions of HIPVs is to provide plants with direct and indirect protection against herbivores. Some of HIPV emissions can be produced also by intact plants with lower quantities. The aim of this study was to measure and quantitatively describe HIPV emission dynamics from Scots Pine (*Pinus sylvestris*) after Scots pine saplings were exposed to bark borer herbivory. Moreover, the formation of secondary organic aerosols (SOAs) caused by emitted VOCs was studied using a flow tube reactor.

To study HIPV emission dynamics, 7-year old Scots pine saplings were exposed to four bark feeding-pine weevils (*Hylobius abietis*) in the laboratory for two days. Each experiment (4 experiments in total) involved two trees each, one control and one treatment tree. Each tree was placed inside a 40 x 100 cm Teflon® bags, and purified air was continuously flushed through the bags at a flow rate of 3.0-4.0 l min^{-1}. VOCs emitted by Scots pine were fed into a flow tube reactor in order to study SOA formation under photochemical oxidation.

The emissions from both trees were continuously measured by proton-transfer-reaction time-of-flight mass spectrometry (PTR-ToF-MS) using an automated valve switching system. PTR-ToF-MS enables rapid and continuous monitoring of plant emissions before and after herbivore damage. To supplement PTR-ToF-MS measurements, cartridge samples were collected twice per day, and analysed offline via thermodesorption- gas chromatography- mass spectrometry (TD-GC-MS). Before the tree was exposed on herbivores, its baseline VOC emission rates were measured for several days. After pine weevils were removed, post-treatment period was monitored for 3-14 days to see how long the emissions remained elevated. High resolution- aerosol mass spectrometer (HR-AMS), and scanning mobility particle sizer (SMPS) were used to monitor SOA formation.

Results

The results showed that the most dramatic change in emissions caused by bark-feeding pine weevils was observed for monoterpene emissions (Figure 1). Pine weevils did have an effect on other compounds, like sesquiterpenes, as well, but a lesser extent. During each experiment pine weevil feeding led to at least a 50-fold increase in monoterpene concentration, and emissions remained elevated for several days. GC-MS analysis showed that many different monoterpenes and sesquiterpenes were emitted by Scots pines with different quantities.

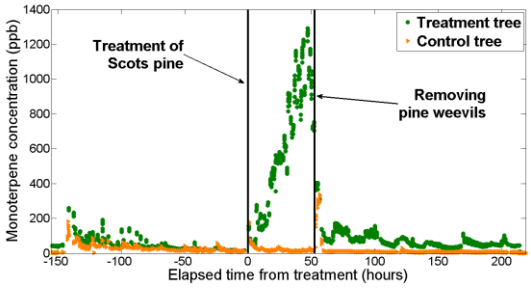

Figure 1. The change in concentration of monoterpenes due to pine weevil feeding during one of the experiments, monitored by PTR-ToF-MS. At time 0 the treatment was started.

The results demonstrate that bark feeding-pine weevils had a large impact on VOC emissions from Scots pine, and especially for monoterpenes. The results also illustrate that it took days before the tree recovered from the herbivore damage after pine weevils were removed. Moreover, the clear increase in SOA was observed after Scots pine was damaged by pine weevils. These results clearly show that herbivores have a significant effect on plant VOC emissions, and suggest that herbivore outbreaks could impact climate by influencing of new secondary organic aerosol precursors emitted by vegetation.

This work was supported by The Academy of Finland Centre of Excellence (grant no 272041), European Research Council (ERC Starting Grant 335478), and University of Eastern Finland Doctoral Program in Environmental Physics, Health and Biology.

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