Emerald Ash Borer Development Rates and Modelling for Potentially Invaded Regions of Canada and Britain

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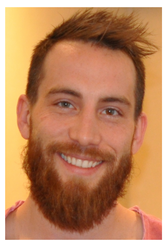


Introduction

Insect pest invasions can be limited by cold tempertures[1,2]. Wood boring pest development can be inhibited[2] or slowed[3], reducing exotic range expansion. Pests such as the pine weevil[4] and two spotted oak borer[2] exhibit variable voltinism throughout their European ranges. Faster generation times with under warmer climate changes would increase economic and ecological damage.

The emerald ash borer (EAB) is the most destructive wood boring invasive species to impact North America, quickly overwhelming novel ash hosts[5,6]. EAB is invading Europe from the Russia in the east, which could be facilitated by increasingly hot summers and interactions with ash dieback[7].

Future climatic changes, broadening the developmental window of EAB, could allow for univoltinism to be more consistent in traditionally cooler climates. Reduction of climatic restrictions could make management efforts more difficult.

Developmental rates are integral for assessing insect pest range expansions. Risk assessments of entry and spread need as much biologically relevant data as possible to increase prediction accuracy.

Objectives

1. Determine the developmental rates of EAB life stages feeding on green and European ash across a range of biologically relevant temperatures.

2. Use these data to build predictive models for EAB development rates in Britain and the rest of the UK under a present and future climate scenarios.

Methods

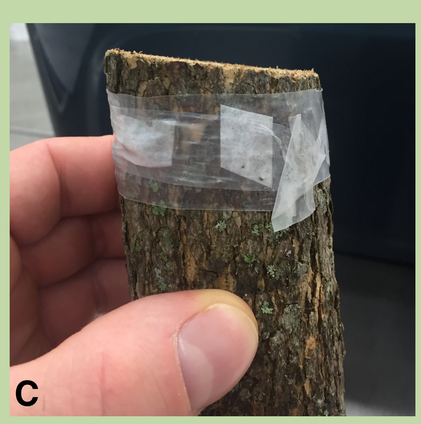
Wild-collected, lab-emerged adults will be paired[A] in mating cups with fresh ash foliage to produce eggs[B].

Egg Hatch
Eggs will be assigned to one of seven temperatures; 7, 10, 13, 17, 21, 25, and 30 °C. Daily checks will determine egg hatching rates.

Larval Development
Eggs will be assigned to one of seven temperatures and a tree species either green or European ash. 10 eggs will be placed on at least 21 "mini-bolts"[C] of ash per treatment (Temp x Ash spp.)

A subset of 3 mini-bolts will be removed at intervals dependent on temp (ie. Every 3 days at 30 °C). Larvae will be excavated[D], measured, and implanted into a fresh mini-bolt to continue development.

Modelling
Data from developmental rate work establish life-stage specific degree day development. Current and future climate models in conjunction with species distribution will use degree day outputs to assess EAB capabilities to complete life cycles in various geographic areas.



Expected Results (1)

Egg Hatch
Eggs are expected to have an increase rate of hatching from 13-30 °C, with both 7 and 10 °C being below the threshold to complete the first life stage. (Fig. 1)

Larval Development
Effect of ash host will have an influence, with a slower growth rate and greater mortality of EAB larvae in European ash. European ash is more phylogenetically related to the native host, Manchurian ash, than green ash[8].

In both ash species 7 °C is expected to below the developmental threshold. A linear decrease in development time is expect as temperatures increase. (Fig. 2)

Adult mean biomass expected to be lower in European ash due to larval energy expenditures used to overcome tree defenses of the more related ash species[8].

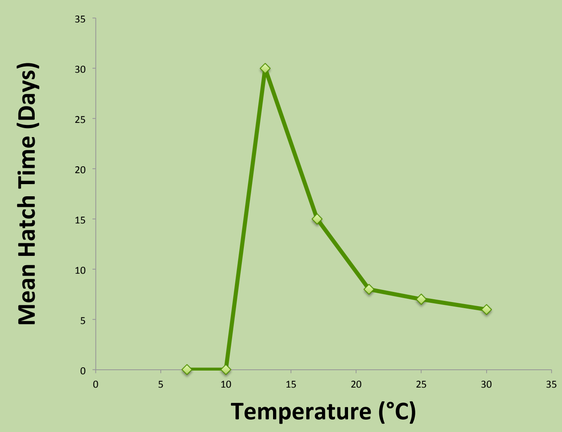


Fig 1. Hypothetical mean EAB egg hatching time across temperature range.

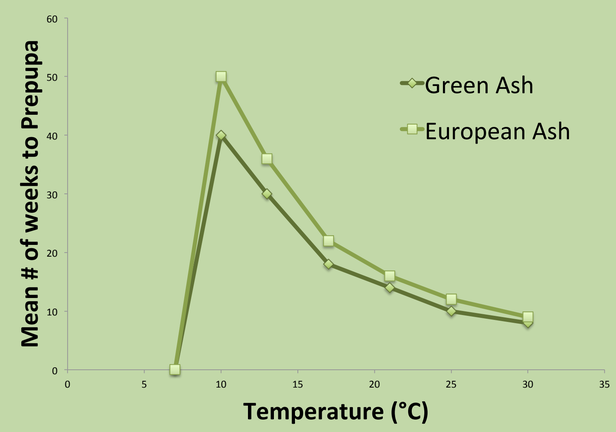


Fig 2. Hypothetical mean time for EAB to reach the prepupal stage in two novel hosts across temperature range.

Expected Results (2)

Modelling
EAB will be capable of developing in all areas with ash species. Invasion depends on if the introduction is facilitated in some cases such as Britain.

We expect the frequency of two-year lifecycles to increase the further north the EAB population is within North America and Europe.

Future Implications

EAB will continue to expands its invasive range in North America and Europe. Diffusive spread from adult flight will slow with an increase in two-year life cycle frequency under current conditions.

These results will allow the assessment of risk of EAB invading Britain and its ability to spread within the island. These data will also enable risk assessment of continued invasive spread and the implications of a warmer future climate on developmental capabilities.

These data are anticipated to be ready to implement in the predictive models in 2020.

Thanks to Tripti Sharma, Tim Ladd, Meghan Gray, and Gene Jones for EAB production support

Photo Legend
A Adult EAB mating, **B** Single EAB egg, **C** 10 EAB eggs held to ash mini-bolt with Parafilm, **D** 3 EAB larvae prior to being measured for head capsule widths.

References

[1]Lyytinen *et al.* 2009 [2]Reed *et al.* 2017 [3]Straw *et al.* 2016 [4]Inward *et al.* 2012 [5]Anulewicz *et al.* 2008 [6]Rebek *et al.* 2008 [7]Orlova-Bienkowskaja *et al.* 2018 [8]Wallander 2008