Feeding preference and response to olfactory cues in the large pine weevil, *Hylobius abietis* (Coleoptera: Curculionidae)

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Contents

• Pest status
• Life cycle
• Control methods
• Integrated Pest Management
• Future implications
• Project aims and objectives
• Materials
• Methods
• Results
• Discussion
• Further research
• Questions

Source: www.forestry.gov.uk
Pest status

• Native to Europe and parts of Asia
• Polyphagous, feeding on most coniferous and some deciduous trees, with a preference for Scots pine (*Pinus sylvestris*)
• Economically important pest for well over 100 years
• Man-made pest of coniferous clear-fell and restocking forestry sites which provide abundance of suitable habitat and where adult herbivory causes seedling mortality

Source: www.forestry.gov.uk
Life cycle

• Eggs laid in or near conifer stumps
• Larvae feed under bark, taking 1-4 years to develop (depending on tree species, abiotic conditions), five instars
• Pupate in soil
• Adults emerge May-September
• Spring - 1\textsuperscript{st} feeding peak (developing flight muscles)
• Disperse (>10km) and mate
• Autumn - 2\textsuperscript{nd} feeding peak (prior to over-wintering)
• Adults longevity – 4 years

Large pine weevil life cycle. Source: www.forestry.gov.uk
Control methods

• Chemical: Prophylactic pesticide treatment of seedlings using Electrodyn Sprayer Conveyor system and alpha-cypermethrin (synthetic pyrethroid), top-up treatments

• Silvicultural: 2-4 year fallow period; soil scarification; planting seedlings with greater resistance; antifeedants/detterants

• Biological: Entomopathogenic nematodes and fungi; natural enemies and parasitoids
Integrated Pest Management

• Over last 10-20 years Forest Research have developed a decision making tool based on forecasted site risk: Hylobius Management Support System

• Uses site-specific monitoring to determine most cost-effective management methods

• Allows timely implementation of combined cultural, chemical and biological control methods

Source: www.forestry.gov.uk
Future implications

- Despite considerable research *Hylobius abietis* continues to cause significant economic damage to coniferous forestry across Europe.
- Current insecticide treatment use is under review.
- Robust alternative methods continue to be sought.

Source: www.fargro.co.uk

Source: www.fsc-uk.org/technical-updates
Project aims and objectives

• This study looked at:
  • Feeding preferences of adult large pine weevils between five tree species
  • The impact of prior weevil herbivory on subsequent herbivory rates
  • Adult weevil responses to olfactory cues from host tree volatiles

• In order to gain understanding of adult feeding behaviour and host preference and to inform Integrated Pest Management strategies including:
  • Interplanting regimes
  • Developing deterrent/antifeeding mechanisms
  • Finding attractants for mass trapping

Source: www.forestry.gov.uk
Materials

• In May-June 2014 adult weevils were collected (using billet traps) from Forestry Commission clear-fell sites on the Cwm Berwyn plantation in Tywi Forest, Cambrian Mountains, Wales (OS Grid Reference: SN 716 572)

• Five tree species: Scot’s pine (*Pinus sylvestris*); Corsican pine (*Pinus nigra* var. *corsicana*); Sitka spruce (*Picea sitchensis*); Silver birch (*Betula pendula*) and European larch (*Larix decidua*)
Methods (1)

• Feeding trials:
  • No choice feeding tests with five tree species
  • Paired choice tests between five tree species
  • Paired choice tests between artificially girdled and non-girdled twigs of same tree species

• Two cut twigs, sealed each end with wax, placed in plastic boxes with one weevil

• Boxes placed inside environmentally controlled Fitotron chamber and weevils allowed to feed for one week

• 9-13 replicates/treatment
Methods (2)

• Y-tube olfactometer trials

• Response to four Scots pine and four Sitka spruce twig treatments:
  • Alone
  • Artificially girdled
  • With feeding wounds from 48 hours exposed to four male weevils
  • With four male weevils present

• Each was tested separately against blank treatments with individual weevils

• After 2 minutes weevils “choice” of treatment, blank, or no-choice was recorded

• 20 replicates/treatment
Methods (3)

• Four-choice olfactometer trials
• Response to two Scots pine treatments
  • Twigs without weevil herbivory
  • Twigs with weevil herbivory
• Treatments were tested separately against three blank treatments
• Individual weevils were allowed to move freely for 10 minutes
• Number of visits per arm and time spent per arm were recorded
• 16-20 replicates/treatment
Results – Feeding Trials

• Weevils consumed all five tree species
• Scot’s pine was consumed the most and Silver birch the least
• Overall hierarchal feeding preference order: Scot’s pine > Sitka spruce > Corsican pine > European larch >> Silver birch

Mean (± s.e.) bark consumption (mm$^2$) in 7-day paired choice feeding experiments between Silver birch and European Larch

Mean (± s.e.) bark consumption (mm$^2$) of five tree species in no-choice 7-day feeding experiments
• Less girdled silver birch was consumed than non-girdled
• Differences in feeding rates between sexes was inconclusive

In 7-day paired choice tests weevils consumed less bark of girdled Silver birch twigs

Mean (± s.e.) bark consumption (mm²) did not differ between sexes in no choice or paired choice tests, but did differ in paired girdled/non-girdled tests
Results - Olfactometer Trials

• Y-tube
  • Indication of positive response to Scots pine volatiles
  • Males showed some aggregation tendencies
  • BUT – strong directional bias

• Four-way
  • Positive response to treatments
  • Males more active than females

In Y-tube trials more weevils chose Scots pine treatment

In four-way trials adults chose/spent more time in the treatment arm than any of the blank/empty arms, females did not make a choice/spent more time the neutral area than males
Difficulties encountered

• Lower than anticipated number of adult weevils collected, possibly due to entomopathogenic nematode trials that were carried out on the Cwm Berwyn site between 2010 and 2012 (pers. comm. Prof. H. Evans *et al.* cited in Williams *et al.*, 2013b)

• Parasitism (*Braconid wasp - Perilitus areolaris*) and mortality during experiments

• Reduced number of replicates

• Pseudoreplication

• Timing issues

• Directional bias in Y-tube olfactometer trials

In Y-tube trials with feeding stimuli more weevils chose the treatment when it was on the right.
Discussion

• Potential impact of results on Integrated Pest Management strategies:
  • Scots pine most susceptible
  • Sitka spruce and Corsican pine also susceptible, not viable alternatives
  • European larch antifeedant properties
  • Deterrent properties of Silver birch
  • Potential of Braconid parasitoid as biological control agent

• Differences between sexes (feeding rates, aggregation, response to olfactory cues) discussed in relation to other studies – generally inconclusive
Further research

• Extending comparisons between tree species to include those used in other studies
• Conducting laboratory and field trials using live seedlings as well as cut twigs
• Investigating male aggregation behaviour in more depth
• Incorporating more treatment options into olfactometer trials, particularly Corsican pine and Silver birch
• Conducting more replicates of trials that had inconclusive results
• Investigating biology, taxonomy and interactions of adult pine weevil parasitoids, which are hugely understudied
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