Do insects that overwinter as adults in British woodland exhibit a preference for south-facing hibernacula?

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Project supervised by Professor John Healey
With thanks to Dr James Walmsley, Course Director
Background
Challenges of overwintering

- Temperate winter conditions can hinder insect metabolism and reproduction
- Various adaptations exist:
  - To reduce risk of cold injury
  - To avoid danger of starvation
  - To lessen risk of predation
- Adaptations can be broadly grouped into **physiological** and **behavioural** ones
- The present study focused on behavioural mechanisms
Behavourial mechanisms

- A common behaviour is to select a microhabitat protected from full effects of adverse conditions:
  - Oviposit or burrow into soil, litter, or plant tissue\(^1\)
  - Crawl under stones or move into dense grass tussocks, hedgerows, or small hollows\(^2\)

- Thought to be controlled by negative phototaxis and positive thigmotaxis\(^2\)


Woodland microhabitats

- It is well established that woodlands offer microhabitats that can dampen variations in ambient temperature:
  - Leaf litter
  - Logs
  - Decayed stumps

- Less well described is the extent to which different microhabitats are used for overwintering by the UK’s insect fauna

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Aim
Overarching objective

- To add to ecological understanding of microhabitats used by insects that overwinter as adults in semi-natural woodland in the UK

- Focused on two groups:
  - Ladybirds (Coccinellidae)
  - Shieldbugs and allies (Coreoidea, Rhopalidea, and Pentatomoidea)
AIM

Specific objective

Based on observations during pilot study:

To investigate if focal species exhibit a preference for south-facing over north-facing hibernacula
Rationale for specific aim

- Preference for south-facing hibernacula would keep body temperature higher.
- Reduced humidity might also be linked to lower burden of fungal infections\(^1\)
  - ... and less chance of wet body surface (internal freezing at higher temperature)\(^1\)
- Existence of orientational preference empirically supported by findings from non-woodland settings for ladybirds\(^1,2\)

\(^1\)Raak-van den Berg CL et al. (2012) Biol Control 60: 68-76.
Methods
A note on power

Anderson (1962) on the collection of overwintering bugs: “extremely time-consuming and unpleasant”

The primary concerns in drawing up the methods were thus to generate reliable results with sufficient power for analysis.

North-side sampling zone

South-side sampling zone

0.5 m

Tree trunk
Statistical testing

- For north–south comparisons, one-tailed Wilcoxon matched-pairs testing was performed according to a hierarchy.
- A result was considered significant if its $P$-value, and all others above it, < 0.05.
- For a post hoc test of foodplant-related preferences of the Birch Shieldbug, $\chi^2$ testing was conducted.
- All statistical analysis was carried out using R 2.6.2 (R Foundation for Statistical Computing).
Results
RESULTS

Sampling conducted

- Stormy weather led to cancellation of two field days and truncation of another
- In addition, not all transects offered 15 trees or shrubs for foliage sampling
- Thus, sampling fell short of targets
  - Leaf litter sampling: 146 trees (81%)
  - Foliage sampling: 112 trees/shrubs (62%)
<table>
<thead>
<tr>
<th>Insect Type</th>
<th>Number of Individuals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cream-spot Ladybird</td>
<td>18</td>
</tr>
<tr>
<td>14-spot Ladybird</td>
<td>15</td>
</tr>
<tr>
<td>7-spot Ladybird</td>
<td>14</td>
</tr>
<tr>
<td>10-spot Ladybird</td>
<td>13</td>
</tr>
<tr>
<td>Orange Ladybird</td>
<td>13</td>
</tr>
<tr>
<td>Birch Shieldbug</td>
<td>18</td>
</tr>
<tr>
<td>Hawthorn Shieldbug</td>
<td>11</td>
</tr>
<tr>
<td>Parent Bug</td>
<td>4</td>
</tr>
<tr>
<td>Hairy Shieldbug</td>
<td>1</td>
</tr>
<tr>
<td>Corizus hyoscyami</td>
<td>1</td>
</tr>
</tbody>
</table>

**Leaf litter ladybirds**

**Leaf litter shieldbugs**
<table>
<thead>
<tr>
<th>Evergreen foliage ladybirds</th>
<th>Evergreen foliage shieldbugs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orange Ladybird</td>
<td>Red-legged Shieldbug nymph</td>
</tr>
<tr>
<td>7-spot Ladybird</td>
<td>1</td>
</tr>
<tr>
<td>Cream-spot Ladybird</td>
<td>11</td>
</tr>
<tr>
<td>Harlequin Ladybird</td>
<td>4</td>
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<tr>
<td>Eyed Ladybird</td>
<td>2</td>
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<td>Hawthorn Shieldbug</td>
<td>10</td>
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<tr>
<td>Bronze Shieldbug</td>
<td>6</td>
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<tr>
<td>Corizus hysocyami</td>
<td>3</td>
</tr>
<tr>
<td>Birch Shieldbug</td>
<td>2</td>
</tr>
<tr>
<td>Green Shieldbug</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>1</td>
</tr>
</tbody>
</table>
RESULTS

North–south comparisons

- All ladybirds in leaf litter: 27–46 (P=0.026)
- All shieldbugs in leaf litter: 10–25 (P=0.007)
- All ladybirds in foliage: 60–87 (P=0.024)
- Orange Ladybirds in foliage: 52–77 (P=0.021)
- All shieldbugs in foliage: 10–13 (P=0.2628)
  - Non-significant
**RESULTS**

**Foodplants: *Post hoc* analysis**

- *Post hoc* analysis conducted to explore if the Birch Shieldbug showed a preference for leaf litter of its foodplants
  - Might reflect convenience of proximity or a strategy to ensure easy food access post-overwintering
- Results revealed a trend towards a preference, but not significant (*P*=0.11)
- Test had limited statistical power
- No other insects with strong foodplant preferences occurred in large numbers
Observations

- Among tree types with at least 10 litter samples conducted, Beech supported greatest insect numbers:
  - Beech, 0.87 insects found per tree (n=15)
  - Hornbeam, 0.82 insects found per tree (n=34)
  - Birch, 0.81 insects found per tree (n=31)
  - Oak, 0.61 insects found per tree (n=56)

- No statistical testing conducted

- Also, various previously unpublished species–hibernaculum pairings found
Discussion
Main findings

- Significant preferences of ladybirds and shieldbugs for leaf litter on the south side of trees
- Significant preferences of ladybirds, including the Orange Ladybird on its own, for evergreen foliage with a southern aspect
Strengths

- Sampling methods were minimally destructive, non-expensive, and efficient
- Indication of overall sampling scheme’s effectiveness can be gained by comparing species of Acanthosomatid and Pentatomid bugs found against a list of known species for 1-km grid squares covered
  - Six of seven Pentatomid bugs found
  - Three of four Acanthosomatid bugs found
DISCUSSION

Limitations

- Would be more ecologically informative to examine how preference varied with temperature and moisture.
- Another improvement to ecological applicability would be to link hibernacula conditions to probability of survival.
- Imperfect standardization of sampling left room for unconscious bias, although less so with leaf litter (could use blinded bags here).
- Variation in conspicuousness also important.
Conclusion
Findings support hypothesis that insects overwintering as adults in woodland favour hibernacula with a beneficial microclimate (as reflected by preference for southern aspects over northern aspects).

Future work is recommended to explore link between hibernaculum preference and microhabitat temperature and moisture, as well as impact on survival.
Questions