Can Manual Sterilisation be effective in controlling the Invasive Signal Crayfish?

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Invasive Species

A species outside of its home range causing adverse effects

Primarily spread by human activities, often unintentionally

Trade, Ornamental plants, Agri/aquaculture

Considered the second largest threat to freshwater ecosystems and their biodiversity

Approximately 42 percent of threatened or endangered species are at risk due to invasive species

~42%
Signal Crayfish  
*(Pacifastacus leniusculus)*

Originated from USA but now widespread across Europe

Introduced by humans, escaped and then spread

Threatens many species including the only UK native freshwater crayfish - White Clawed Crayfish *(Austropotamobius pallipes)*

Introduced in 1960’s for aquaculture
Signal Crayfish  
(Pacifastacus leniusculus)

- Maximum size of ~18cm
- Predation and competition
- High reproductive rate with one breeding season October - November
- Lay up to 400 eggs - competition
- Benthic (live on riverbed) burrow under rocks or in riverbank
- Bank erosion and instability
- Typically occur in high densities
- Outcompete native fauna
- Herbivores, detrivores and carnivores
- Adaptable to new environments and predation
- Asymptomatic carriers of the crayfish plague (Aphanomyces astaci)
Impacts

Distribution of Signal crayfish in Europe - Kouba et al. 2014
Although it is best to eradicate early on in a species invasion, it can be done at any time.
In This Study...

- Aimed to inhibit external fertilisation and reproductive success
- Manual Sterilisation of the gonopods (male genitals)
- Tested its effects on:
  - Spermatophore distribution
  - Brood size (no. of fertilized eggs)
- Other considerations:
  - Carapace length
  - Gonopod area
  - Chelae asymmetry/damage
## Method - - Treatments

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Sterilisation Status</th>
<th>Number of individuals</th>
<th>Collection Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Not sterilised (control)</td>
<td>9</td>
<td>September 2019</td>
</tr>
<tr>
<td>2</td>
<td>Cutting whole gonopods</td>
<td>9</td>
<td>September 2019</td>
</tr>
<tr>
<td>3</td>
<td>Pulling off whole gonopods</td>
<td>9</td>
<td>September 2019</td>
</tr>
<tr>
<td>4</td>
<td>One year gonopod regrowth (trimmed once)</td>
<td>9</td>
<td>September 2018</td>
</tr>
<tr>
<td>5</td>
<td>One year gonopod regrowth (trimmed twice)</td>
<td>5</td>
<td>September 2017</td>
</tr>
</tbody>
</table>

- All crayfish sourced from same fishery in Dorset
- Housed outside to keep ambient temperature (n < 12)
- Males and females housed separately
- Gravel bottom and PVC pipes as refuges
- Fed a carrot diet fortnightly
Method - Copulations

- All copulations between 17th – 24th October
- Size-matched
- Acclimatised for 5 minutes and left together for 30 minutes or until successful copulation
- Number individuals and record biometrics
- Photographs of spermatophore distribution and gonopod size (T1, 4 & 5)
- Males euthanised, females housed in new tanks outside in equal densities ($n = 9$)
Method – Image Analysis

- Spermatophore placement and gonopod size/regrowth was quantified using ImageJ software
Method – Egg collection

- All eggs were quantified on the same day in February
- Pulled off using tweezers and counted by eye
- Females then euthanised
# Results – Spermatophore Cover

A comparison of the means for spermatophore percentage cover between all the *Pacifastacus leniusculus* treatments.

**Significance**

<table>
<thead>
<tr>
<th>Treatments Compared</th>
<th>T-test</th>
<th>Bonferroni-corrected P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>t</td>
<td>d.f</td>
</tr>
<tr>
<td>Not sterilised (control) Cutting whole gonopods</td>
<td>3.394</td>
<td>16</td>
</tr>
<tr>
<td>Not sterilised (control) Pulling off whole gonopods</td>
<td>2.574</td>
<td>16</td>
</tr>
<tr>
<td>Not sterilised (control) One year gonopod regrowth (trimmed once)</td>
<td>2.910</td>
<td>16</td>
</tr>
<tr>
<td>Not sterilised (control) One year gonopod regrowth (trimmed twice)</td>
<td>2.559</td>
<td>12</td>
</tr>
<tr>
<td>Cutting whole gonopods Pulling off whole gonopods</td>
<td>0.586</td>
<td>16</td>
</tr>
<tr>
<td>One year gonopod regrowth (trimmed once) One year gonopod regrowth (trimmed twice)</td>
<td>0.805</td>
<td>12</td>
</tr>
</tbody>
</table>

**Spermatophore cover of the signal crayfish treatments.**

- Not sterilised (control): Cutting whole gonopods (p = 0.03)
- Not sterilised (control): Pulling off whole gonopods (p = 0.11)
- Not sterilised (control): One year gonopod regrowth (trimmed once) (p = 0.12)
- Not sterilised (control): One year gonopod regrowth (trimmed twice) (p = 0.13)
- Cutting whole gonopods: Pulling off whole gonopods (p = 1.00)
- One year gonopod regrowth (trimmed once): One year gonopod regrowth (trimmed twice) (p = 1.00)
## Results – Spermatophore Distribution

### Average Spermatophore Distribution

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Two Middle Pair of Legs</th>
<th>Two Outer Pair of Legs</th>
<th>Tail</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>1</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Cutting whole gonopods</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Pulling off whole gonopods</td>
<td>5</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>One year gonopod regrowth (trimmed once)</td>
<td>4</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>One year gonopod regrowth (trimmed twice)</td>
<td>2</td>
<td>1</td>
<td>4</td>
</tr>
</tbody>
</table>

### Significance

A ranking comparison of spermatophore distribution between the signal crayfish treatments.

<table>
<thead>
<tr>
<th>Treatments Compared</th>
<th>T-test</th>
<th>d.f</th>
<th>p</th>
<th>Bonferroni-corrected P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not sterilised (control)</td>
<td>Cutting whole gonopods</td>
<td>5.971</td>
<td>8.925</td>
<td>0.00</td>
</tr>
<tr>
<td>Not sterilised (control)</td>
<td>Pulling off whole gonopods</td>
<td>6.157</td>
<td>8.680</td>
<td>0.00</td>
</tr>
<tr>
<td>Not sterilised (control)</td>
<td>One year gonopod regrowth (trimmed once)</td>
<td>5.169</td>
<td>16</td>
<td>0.00</td>
</tr>
<tr>
<td>Not sterilised (control)</td>
<td>One year gonopod regrowth (trimmed twice)</td>
<td>4.354</td>
<td>12</td>
<td>0.00</td>
</tr>
<tr>
<td>Cutting whole gonopods</td>
<td>Pulling off whole gonopods</td>
<td>0.455</td>
<td>16</td>
<td>0.655</td>
</tr>
<tr>
<td>One year gonopod regrowth (trimmed once)</td>
<td>One year gonopod regrowth (trimmed twice)</td>
<td>0.356</td>
<td>12</td>
<td>0.728</td>
</tr>
</tbody>
</table>

A comparison of spermatophore deposited between the **two middle pair of legs** between all the signal crayfish treatments.
Results – Spermatophore Distribution
The total brood size (a) and the number of individuals who had fertile eggs (b) from the different signal crayfish treatments. Note that one year gonopod regrowth (trimmed twice) brood size is an estimated frequency as a result of the smaller sample size (n = 5).

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Total Brood Size</th>
<th>Average Brood Size</th>
<th>% of Individuals With Fertilised Eggs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>315</td>
<td>35</td>
<td>55.6</td>
</tr>
<tr>
<td>Cutting whole gonopods</td>
<td>416</td>
<td>46.22</td>
<td>44.4</td>
</tr>
<tr>
<td>Pulling off whole gonopods</td>
<td>34</td>
<td>3.78</td>
<td>22.2</td>
</tr>
<tr>
<td>One year gonopod regrowth (trimmed once)</td>
<td>130</td>
<td>14.44</td>
<td>22.2</td>
</tr>
<tr>
<td>One year gonopod regrowth (trimmed twice)</td>
<td>1.8</td>
<td>0.20</td>
<td>20</td>
</tr>
</tbody>
</table>
Results – Relationship Between Carapace Length and Gonopod Area

Adjusted gonopod area

$CL \div \text{Gonopod Area}$

Where:
- $CL$ is the Carapace Length (mm)
- \( \text{Average Gonopod Area} \) (mm\(^2\))

The graph illustrates the relationship between carapace length and gonopod area for different trimming conditions: Never Trimmed, Trimmed Once, and Trimmed Twice.
Results – Effect of Gonopod Regrowth on Adjusted Gonopod Area

The combined adjusted gonopod size (average of all four)

Each gonopod’s adjusted size from the treatments
Results – Relationship Between Adjusted Gonopod Size and Spermatophore Cover

No Strong Relationship
($r^2 = 0.314$)
The abundance of female experimental signal crayfish individuals categorised into chelae damage and their egg production

No Significance (p = 0.740)

The abundance of chelae damaged and undamaged male experimental signal crayfish individuals categorised into spermatophore cover groups.

No Significance (p = 0.786)
Tested the effects of manual sterilisation on:

- **Spermatophore placement**
  - More disperse
    - All treatments against the control was statistically significant
  - Less spermatophore deposited
    - Only cutting gonopods against the control was significant

- **Brood size** (no. of fertilized eggs)
  - Sterilisation appeared to reduce brood size
    - However not statistically significant
  - % of females with fertilised eggs smaller when mated with sterilised males
More research is needed

An integrated multi-method approach may be more effective:

- Funnel trapping (small male and female euthanisation)
- Sterilise larger, more dominant males
- Reduce water level (to increase predation – especially of small young hatchlings)
Thank You For Listening

Any Questions?