USE OF CONDITION INDEX FOR MUSSEL HEALTH ASSESSMENT

Serena Ciparis, Ty Stephenson, Garrett Rhyne, and Susan Lingenfelser
• Allocation of energy stored in soft tissue
• Weight of tissue normalized to ‘size’

• Fish (Heincke, 1908):
  • Fulton’s condition factor \((K) = \left( \frac{\text{weight (g)}}{\text{length (cm)}^3} \right) \times 100\)

• Bivalves (Higgins, 1938):
  • Condition index = tissue dry weight (g) / shell cavity volume (ml)

• Freshwater bivalves (modern)
  • Condition index = tissue weight (g) / “something related to the shell”
C.I. IN FRESHWATER BIVALVE LITERATURE

Search terms: “Condition index” AND (“freshwater mussel” or “freshwater bivalve”)

<table>
<thead>
<tr>
<th>Calculation</th>
<th>Year published</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tissue wet weight / length</td>
<td>2017</td>
</tr>
<tr>
<td>Tissue dry weight / length ^3</td>
<td>2011</td>
</tr>
<tr>
<td>(Tissue wet weight / shell dry weight) * 100</td>
<td>2017</td>
</tr>
<tr>
<td>(Tissue dry weight / shell dry weight) * 100</td>
<td>2017</td>
</tr>
<tr>
<td>Tissue wet weight / shell cavity volume</td>
<td>2015</td>
</tr>
<tr>
<td>(Tissue dry weight / shell cavity volume ) * 1000</td>
<td>2015</td>
</tr>
</tbody>
</table>
• Measured biochemical endpoints upstream and downstream of WWTPs
• *Lampsilis fasciola (2 yrs old), 8 wk. exposure

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**Condition index (g d.w./ cm^3)**

- **BSG**
  - **UP**
  - **DS**

- **PENN**
  - **UP**
  - **DS**

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**Glycogen in mantle (mg / g)**

- **BSG**
  - **UP**
  - **DS**

- **PENN**
  - **UP**
  - **DS**

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**Conductivity > 900 µS/cm upstream**

**Chlorinated effluent**
LABORATORY EXPOSURE

- Do elevated concentrations of major ions affect energy storage in mussels?

- Simulated Powell River water (conductivity ~1,000 µS/cm)
  - No effect on growth of juvenile *Villosa iris* (Ciparis et al. 2015)

- Added a sediment treatment
  - Powell River, coal = 1.5 % dry weight

- Adult *L. fasciola* (5 years old), 6 wk. exposure
• **Biochemical markers (Garrett)**
  - Glycogen in mantle tissue, glutathione-dependent enzymes in digestive gland

• **Multiple methods of measuring condition index (Ty)**
  - Weight (g) / length (cm)^3 of live mussels
  - Weight (g) / volume (ml; displacement) of live mussels
  - Tissue weight (wet and dry; g) / shell cavity volume (ml; capacity of 1 valve * 2)
  - Tissue weight (wet and dry; g) / shell cavity weight (g)
    - Shell cavity weight = whole wet weight – dry shell weight (Crosby and Gale, 1990)
  - Tissue dry weight (g) / length (cm) ^3
<table>
<thead>
<tr>
<th>Method</th>
<th>Water</th>
<th>Sediment</th>
<th>Sex</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight (g) / length (cm) ^3 - live</td>
<td>-</td>
<td>-</td>
<td>p=0.0004</td>
</tr>
<tr>
<td>Weight (g) / volume (ml) - live</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Tissue w.w. (g) / shell cavity volume (ml)</td>
<td>p=0.06</td>
<td>-</td>
<td>-</td>
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<tr>
<td>Tissue d.w. (g) / shell cavity volume (ml)</td>
<td>p=0.011</td>
<td>-</td>
<td>-</td>
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<tr>
<td>Tissue w.w. (g) / shell cavity weight (g)</td>
<td>p=0.015</td>
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<tr>
<td>Tissue d.w. (g) / shell cavity weight (g)</td>
<td>p=0.003</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Tissue d.w. (g) / length (cm) ^3</td>
<td>p=0.015</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
• Significant difference between water treatments (CW vs. PW) for dissected mussels only
• Best measure = tissue dry weight / shell cavity weight
BIOCHEMICAL RESULTS

- Significant difference (p=0.014) in mantle glycogen content between water treatments (CW vs. PW) for males only.

- Activity of glutathione reductase (GR) was significantly higher in females (p=0.0087); no effect of treatment.

\[ \text{GSSG + NADPH + H}^+ \rightarrow 2 \text{GSH + NADP} \]
CONCLUSIONS

• All mussels ‘got thinner’ when exposed to simulated Powell River water
  • No effect of coal-contaminated sediment
  • No effect of sex

• Lower glycogen content in mantle tissue in males only

• Females were likely using energy (lipids) from resorbing gametes
  • More available energy for glutathione reductase

• Elevated concentrations of major ions affect energy storage in adult freshwater mussels
  • Did we miss something by only measuring growth in juveniles in our first exposure (Ciparis et al. 2015)?

• Condition index is a worthwhile measurement
MEASURING CONDITION INDEX

- Dissect your mussels whenever possible, take measurements

- Can be used for juveniles
  - Whole wet weight, whole dry weight, shell ‘ashed’ weight

- Follow the recommendations of Crosby and Gale (1990)
  - C.I. = tissue dry weight (g) *1000 / shell cavity weight (g)