The importance of temperature: an ecologist perspective

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It is not all ecology: Svante August Arrhenius

But:
• Only real hydrological data in a few places
• No fine scale measurements
• Hit-and-run type of sampling
But it also about never being too old to play!

Climate change will impact ecosystem services both directly and indirectly (via the food web)
## Climate change

<table>
<thead>
<tr>
<th>Component</th>
<th>Ecological Consequence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature</td>
<td>Elevated metabolic demands</td>
</tr>
<tr>
<td>Hydrology</td>
<td>Habitat fragmentation and degradation</td>
</tr>
<tr>
<td>Phenology</td>
<td>Consumer-resource mismatches</td>
</tr>
<tr>
<td>Wildfires</td>
<td>Manifold effects of riparian vegetation loss</td>
</tr>
<tr>
<td>Atmospheric change</td>
<td>Altered consumer-resource stoichiometry</td>
</tr>
<tr>
<td>Invasive species</td>
<td>Emergence of novel food webs</td>
</tr>
</tbody>
</table>

### Metabolism – temperature and body size

\[
B_i = b_0 e^{-\frac{E}{kT}} M_i^\alpha
\]

Temperature

Body mass

Metabolic Theory of Ecology (Brown et al. 2004). Individual metabolic rate scales with temperature and body mass.....
The play ground
Research area: Hengill, Iceland

Woodward et al. 2010, Global Change Biology
Aim of this study

› To test, using existing data sets, if temperature or indicators of hydraulic stability was the main driver of macroinvertebrate community composition along a latitudinal gradient from Denmark (55°N) in the South to Greenland (69°N) in the North.

› To investigate the relationship between leaf litter breakdown, as a proxy of ecosystem functioning, and temperature.
Data sets

» The data set in which we tested macroinvertebrate community composition in relation to environmental variables comprised of in total 49 sites, with 21 from Denmark; 14 from Iceland and 14 from Greenland

» Leaf litter breakdown analyses were based on data from 23 sites with 4 from Denmark; 9 from Sweden and 10 from Iceland.
Danish sites

Greenland sites
Greenland /2

Iceland sites
Analysis

**Macroinvertebrate community analyses**

› Independent analysis of the 3 data sets using the same analytical approach
  › Sampling strategy and purpose
  › Slightly different methods used
  › Large differences in regional species pools

**Ecosystem functioning**

› Analysed together
  › Similar method – leaf litter decomposition
  › Controlled for temperature – logged for the duration of study
  › Only fine mesh used
    › No physical abrasion = little hydrological/stability influence
    › Not accessible to macroinvertebrates = minimal regional influence

<table>
<thead>
<tr>
<th>Country</th>
<th>Temperature (°C)</th>
<th>&quot;Stability&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Denmark (55 to 57°N)</td>
<td>10.2-14.5</td>
<td>0-10.6 Fre7</td>
</tr>
<tr>
<td>Iceland (64°N)</td>
<td>4.7-23.4</td>
<td>0-78 % plant cover</td>
</tr>
<tr>
<td>Greenland (66 to 69°N)</td>
<td>2.7-17.3</td>
<td>15-59 Pfankuch index</td>
</tr>
</tbody>
</table>
Analytical approach

› Multivariate analysis of variance using the Bray-Curtis distance matrix
› Analysis of multivariate homogeneity of group dispersions (variances) is calculated using Bray-Curtis distance matrix

Based on grouping of the environmental data available

Example – Greenland/temperature

› Data from the 14 < 100 m sites
› No size (width) – temp relationship $p > 0.05$
› No Pfankuch – temperature relationship $p > 0.05$
Iceland macroinvertebrates – temperature groups

› P < 0.001

Iceland macroinvertebrates – stability (cover of vegetation)

› P > 0.05
Measure of variance (beta diversity) 
temperature - Iceland

Temperature; p < 0.05
Average distance to centroid cold: 0.4468, warm: 0.2916

Greenland macroinvertebrates 
temperature groups

P<0.05

A significant grouping was also found for Danish sites 
with regard to temperature (p<0.05)
Macroinvertebrate community analysis

Summary

› A significant temperature effect was found either in both or one of the analyses of groups across the latitudinal gradient from Denmark to Greenland

› No significant differences were found with regard to groups that were separated by indicators of hydraulic stability

› Similarly, water chemistry had no significant effects
Conclusions

- Our study indicate that temperature has an influence on macroinvertebrate community composition across a latitudinal gradient and is a strong driver of ecosystem functioning.
- The rise in temperature is likely to be instrumental in shaping communities but it is difficult to predict how adaptive the majority of species will be.
- It is predictable, however, that metabolic rates will increase and the whole ecosystem functioning is likely to change.
- There is an urgent need to explore these general patterns in Northern catchments to increase our ability to predict the change to come.