The influence of invasive species cover on different biological communities in temperate ponds

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The aquatic ecosystem

- Aquatic system **without alien plant**
- Interaction biological communities
- Key-role for native macrophytes (Scheffer et al. 1993; Jeppesen et al. 1998)
With **ALIEN PLANT** -> part of the food web

-> factors density and identity of the alien plant, habitat quality, nutrient loading (Villamagna 2009)
Target species

Myriophyllum aquaticum  Ludwigia grandiflora  Hydrocotyle ranunculoides

Introduced through the aquarium trade
Amphibious growth
Tolerance to wide range of nutrient levels
Vegetative reproduction
Rapid and extensive growth
Ecological and economical impacts
**General aim:** interaction of the invasive macrophytes with different biological communities and the extent of their impact

**3 major objectives:**

1) To investigate the association between invasive plant cover and native plant cover and the impact on native plant species richness

2) To investigate phytoplankton and zooplankton communities along a gradient of invasive species cover

3) To investigate the threat of an invasive species (*L. grandiflora*) on pollinator services

**Hypothesis** = invasive plant cover has an influence in shaping the outcome of impact
L. grandiflora: 5% cover
L. grandiflora: 25% cover
M. aquaticum: 75% cover
H. ranunculoides: 100% cover
M&M - I. NATIVE PLANTS, ZOOPLANKTON and PHYTOPLANKTON

18-32 waterbodies focus on nature reserves, small (< 1ha) and shallow (max. 4m)

- POND
  - native vegetation cover
  - zooplankton density and composition
  - phytoplankton biovolume and composition

- PLOT
  - native plant species richness

Invaded ponds

Uninvaded ponds

Not yet invaded A plots

Semi-invaded B plots

Heavily invaded C plots
RESULTS - I. NATIVE PLANTS: species richness and cover

Lower species richness and decrease of native vegetation cover due to habitat modification and competition

Stiers et al. (2011) Biol. Invasions
RESULTS - II. PHYTOPLANKTON/ZOOPLANKTON: biovolume, density and composition

**phytoplankton biovolume and composition**

- Neutral effect

**zooplankton density and composition**

Most of the zooplankton present ($r_s = -0.66$, $P = 0.02$)

**Macrophyte-associated taxa** only present in uninvaded ponds
Lower zooplankton density due to continual low O$_2$ levels, physical hampering and putative allelopathic property

**RESULTS - II. ZOOPLANKTON: variation**

- **Uninvaded ponds** with submerged vegetation (SC) associated with clear water state and various zooplanton taxa

- **Variation partitioning:**

<table>
<thead>
<tr>
<th>Variation</th>
<th>Zooplankton variation explained (%)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>[ENV + EXOT]</td>
<td>50.2</td>
<td>0.001</td>
</tr>
<tr>
<td>[ENV]</td>
<td>41.9</td>
<td>0.001</td>
</tr>
<tr>
<td>[EXOT]</td>
<td>17.9</td>
<td>0.03</td>
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<tr>
<td>[ENV</td>
<td>EXOT]</td>
<td>32.3</td>
</tr>
<tr>
<td>[EXOT</td>
<td>ENV]</td>
<td>8.3</td>
</tr>
<tr>
<td>[ENV &amp; EXOT]</td>
<td>9.6</td>
<td>0.12</td>
</tr>
<tr>
<td>1 - [ENV + EXOT]</td>
<td>49.8</td>
<td>0.11</td>
</tr>
</tbody>
</table>

Triplot of the first two axes of a PCA on the different ponds and their relationship with local environmental variables with zooplanton taxa as supplementary variables explaining 57.8% of the total variation.
ZOOPLANKTON experiment

7 invasive sp. (3 amphibious, 3 free-floating, 1 submerged)

- *Eichhornia crassipes*
- *Pistia stratiotes*
- *Salvinia molesta*
- *Hydrocotyle ranunculoides*
- *Ludwigia grandiflora*
- *Myriophyllum aquaticum*
- *Elodea nuttallii*
Plant-pollinator interactions

Pollinator sharing

Facilitation

↑ visitation rate
↑ conspecific pollen transfer
↑ native seed production

Competition

↓ visitation rate

Native species
Invasive species

Native species
Invasive species

Facilitation

Competition

↑ visitation rate
↑ conspecific pollen transfer
↑ native seed production

↓ visitation rate

Reviewed in Bjerknes et al. (2007)
Plant-pollinator interactions

Pollinator sharing

Facilitation

- ↑ visitation rate
- ↑ conspecific pollen transfer
- ↑ native seed production

Native species

Invasive species

Competition

- ↓ visitation rate
- ↓ seed production
- 1: interspecific pollen transfer
- 2: native seed production

Native species

Invasive species

Reviewed in Bjerknes et al. (2007)
M&M - III. POLLINATOR SERVICES: pollinator visitation

2 ponds, 6 native *L. salicaria* plants in an array, 4 observation days

- foraging behaviour
- visitation rate
RESULTS - III. POLLINATOR SERVICES: pollinator visitation and foraging behaviour

- **facilitation effect**

- **neutral effect**

Facilitation of visitation due to increase in floral display

Key step is to know what happens at the stigma level
M&M - III. POLLINATOR SERVICES: pollen transfer and seed set

Fluorescent dye as pollen analogues to track IPT

50 flowers

Dye appliance on donor plants

1 day

Honey bee with pink dye

3 ponds

no cover

low cover

high cover

Stigma collecting of recipient plants (ca. 5000 stigmas)

Blue dye under UV microscope
RESULTS - III. POLLINATOR SERVICES: pollen transfer and seed set

- **Interspecific pollen transfer and seed set**

![Graph showing interspecific pollen transfer and seed set with statistical significance levels and legend labels for different areas and cover types.]

- No difference in proportion stigmas with **conspecific dye** for *L. salicaria* between invaded and uninvaded sites (high dye loads > 0.75)

- Higher proportion of stigmas with **invasive dye** for *L. salicaria* in the high cover site (HPD restricted < 50% of stigmas visited)

- Neutral effect on seed set

**High conspecific dye loads, low HPD and no effect on seed set due to restricted pollinator switching and possible mechanical isolation**
POLLEN TRANSFER experiment

Lu = L. grandiflora = invasive sp.

Ly = L. salicaria = native sp.

A = Alisma plantago-aquatica = native sp.

3 blocks

Pollen transfer simulation on L. salicaria in presence of L. grandiflora

Pollen transfer simulation on A. plantago-aquatica in presence of L. grandiflora
Main conclusions

- we observed significant **negative relationships** between **invasive species cover** and native vegetation cover and zooplankton density. Invasive species cover had **no influence on phytoplankton** biovolume.

- an invasive species cover of < 25 % was still associated with submerged vegetation and macrophyte-associated zooplankton genera, while a **cover of > 50 %** harboured almost no submerged vegetation and no littoral zooplankton.

- the presence of high abundance of *L. grandiflora* **facilitated** pollinator visits to native *L. salicaria* but this was not translated in increased seed set. In general **IPT was restricted** but we found more HPD on *L. salicaria* stigmas at dense cover of *L. grandiflora*.

Impacts can be -, ≈ or even + but are related to cover of the alien plant
Thanks to...