Restoring faunal communities: mechanisms and constraints

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Overview

Knowledge for restoration

Problem

1. Bottom up (Life-history tactics)

2. Top down (Red-backed shrike)

Conclusions and recommendations
Knowledge

How to restore degraded ecosystems?

‘Match’ between species and environment

- Species’ biology
- Environmental conditions
- Impact of degradation
- Effect of restoration
Knowledge

Scaling effects
How to restore degraded ecosystems?

‘Match’ between species and environment

- Species’ biology
- Environmental conditions
- Impact of degradation
- Effect of restoration
- Scale
Problem

How to make sense of the large diversity in species - environment relationships?

- Scaling effects
- Intraspecific differences (during life cycle)
Flora

Fauna

Biogeochemistry & Hydrology

Higher plants ~ 1,400 species
Animals ~ 24,000 species
Problem

How to make sense of the large diversity in species - environment relationships?

- Scaling effects
- Intraspecific differences (during life cycle)
- Interspecific differences (many species)

Aggregation
1. Life-history tactics in aquatic invertebrates
Selection
2. Red-backed shrike in coastal dunes
Life-history tactics in aquatic invertebrates

How to make sense of the large diversity in species - environment relationships?

Aggregate species with similar functional relations to their environment

Species traits - causal mechanisms
Life-history tactics in aquatic invertebrates

How to make sense of the large diversity in species traits?

Development time  Passive dispersal  
Morphology  Egg size  
Diapause stage  Adult life span  
Diapause period  Egg number  
Dispersal capacity  Number of clutches  
Active dispersal  ...

Combine traits in **life-history tactics**

“a set of co-adapted traits designed, by natural selection, to solve particular ecological problems”  
Stearns, 1976
Life-history tactics in aquatic invertebrates

Trade-off
Investments in one trait $\rightarrow$ less resources for another trait.

Growth and development
Egg size and egg number

...
Life-history tactics in aquatic invertebrates

Trade-off
Investments in one trait → less resources for another trait.

Growth and development
Egg size and egg number
...

Functional combination
Investments in one trait → increases benefits or lowers costs for another trait.

Few eggs and brood care
Gills in damselflies for respiration and locomotion
...
Life-history tactics in aquatic invertebrates

How to make sense of the large diversity in species traits?

Different traits combinations may be functionally similar

Egg protection:
- endophytical oviposition
- gelatinous matrix
- brood care
- ovoviviparous
Life-history tactics in aquatic invertebrates

How to make sense of the large diversity in species traits?

Interrelations between traits
Functional interpretation

\{ 13 life-history tactics \}
Life-history tactics in aquatic invertebrates

Synchronisation tactics
- S1: Strong dispersal
  - S2: Synchronised juvenile development
  - S3: No resistant stages
  - S4: No active flight

Dispersal tactics
- D1: Long growth period
  - D2: Short growth period

Developmental trade-off tactics
- T1: High tolerance
  - T2: No active flight

Reproduction tactics
- R1: No active flight
  - R2: Slow growth, moderate per capita investment
  - R3: Rapid growth, high per capita investment
  - R4: Asexual reproduction
Life-history tactics in aquatic invertebrates

Application to evaluate effects of rewetting measures in raised bogs
Case study Korenburgherveen

45 waters sampled
  • spring (April-May)
  • autumn (September-November)

209 samples

Aquatic invertebrate groups identified:

<table>
<thead>
<tr>
<th>Scientific name</th>
<th>Common name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tricladia</td>
<td>Flatworms</td>
</tr>
<tr>
<td>Hirudinea</td>
<td>Leeches</td>
</tr>
<tr>
<td>Coleoptera</td>
<td>Beetles</td>
</tr>
<tr>
<td>Hemiptera</td>
<td>True bugs</td>
</tr>
<tr>
<td>Odonata</td>
<td>Dragonflies &amp; Damselflies</td>
</tr>
<tr>
<td>Trichoptera</td>
<td>Caddisflies</td>
</tr>
<tr>
<td>Chaoboridae</td>
<td>Phantom midges</td>
</tr>
<tr>
<td>Chironomidae</td>
<td>Nonbiting midges</td>
</tr>
<tr>
<td>Dixidae</td>
<td>Meniscus flies</td>
</tr>
<tr>
<td>Rest (e.g. Asellus aquaticus, Argyroneta aquatica)</td>
<td>Waterspider, Aquatic sowbug</td>
</tr>
</tbody>
</table>

>145,000 individuals
267 taxa
Rewetting measures in raised bog with tactics

- Increase retention of rainwater
- Decrease drainage
Evaluating effects of rewetting measures in raised bog with tactics

Water bodies in forest

- Higher water table
- Stagnation
- Mobilisation of nutrients
- Increase of *Glyceria maxima*

More variable and unpredictable environment
Evaluating effects of rewetting measures in raised bog with tactics

More groundwater influence
Cyclic, predictable environment
Evaluating effects of rewetting measures in raised bog with tactics

![Graph showing abundance of species before and after measures with categories and significance levels.]

Risk spreaders
Stress tolerators
Synchronisers

Life-history tactic
Evaluating effects of rewetting measures in raised bog with tactics

Bog pools

- Higher water table
- Stagnation
- Less groundwater

More harsh and constant environment
Evaluating effects of rewetting measures in raised bog with tactics

Bog pools

Not a harsher environment
Evaluating effects of rewetting measures in raised bog with tactics

Stress tolerators
Synchronisers

Abundance (%)

T1
S1+S2

Life-history tactic

n.s.

*
Evaluating effects of rewetting measures in raised bog with tactics

**a**

<table>
<thead>
<tr>
<th>Life-history tactic</th>
<th>Abundance (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2- T1,R1+R3</td>
<td>60 ± 10</td>
</tr>
<tr>
<td>2+</td>
<td>65 ± 5</td>
</tr>
<tr>
<td>2- S1,S2,S3 + S4</td>
<td>40 ± 15</td>
</tr>
<tr>
<td>2+</td>
<td>50 ± 10</td>
</tr>
</tbody>
</table>

* p=0.97

**b**

<table>
<thead>
<tr>
<th>Life-history tactic</th>
<th>Abundance (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3- T1</td>
<td>70 ± 5</td>
</tr>
<tr>
<td>3+</td>
<td>75 ± 20</td>
</tr>
<tr>
<td>3- S1+S2</td>
<td>25 ± 5</td>
</tr>
<tr>
<td>3+</td>
<td>30 ± 10</td>
</tr>
</tbody>
</table>

* n.s.
Evaluating effects of rewetting measures in raised bog with tactics

Rewetting measures as a filter, causing a functional homogenisation
Evaluating effects of rewetting measures in raised bog with tactics

functional homogenisation decreases species number
Evaluating effects of rewetting measures in raised bog with tactics

Groundwater influence:

• Stable, minerotrophic transitions (biodiversity hotspots)
• Minerotrophic influence important for primary and secondary succession
• Important driver for landscape heterogeneity

Restore regional groundwater is a more promising restoration strategy
Problem

How to make sense of the large diversity in species - environment relationships?

Aggregation
Selection

1. Life-history tactics in aquatic invertebrates
2. Red-backed shrike in coastal dunes
Red-backed shrike in coastal dunes

Europe-wide decline of Red-backed shrike (*Lanius collurio*)  
Tucker & Heath (1994)
Strong decline in coastal dunes
Red-backed shrike in coastal dunes

Effects of nitrogen deposition

Hanstholm, Denmark

1991

Hanstholm, Denmark

2001
Red-backed shrike in coastal dunes

- seasonal migrating
- single prey, large prey
- diverse diet
  (large insects & small vertebrates)
Red-backed shrike in coastal dunes

Diet contribution of odonata species

Seasonal and diurnal shifts in prey choice
Diverse diet needed for sufficient food during breeding period
Red-backed shrike in coastal dunes

Testing the foodweb hypothesis...

Degraded

Last Dutch pairs in 1998/1999 on Ameland, Netherlands

Intact

Vital population in Skagen, Denmark
Red-backed shrike in coastal dunes

Consumption by nestlings

Consumption per nestling per day (mg DW)

age of nestlings (days)

Ameland nestlings
- '97 (3)
- '98 (3 > 1)

Skagen
- SK1 (5)
- SK12 (6)
- SK16 (4)
Red-backed shrike in coastal dunes

Food is sufficient for the needs of the few or the one

Consumption by nestlings
Red-backed shrike in coastal dunes

Prey size in adult diet

Degradation associated with smaller prey
## Red-backed shrike in coastal dunes

### Diet composition

<table>
<thead>
<tr>
<th></th>
<th>Ameland '89</th>
<th>Ameland '97-'98</th>
<th>Terschelling '94-'95</th>
<th>Skagen '02</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beetles</td>
<td>79,0</td>
<td>34,5</td>
<td>25,7</td>
<td>56,1</td>
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<tr>
<td><em>Scarabids</em></td>
<td>49,5</td>
<td>3,9</td>
<td>7,0</td>
<td>46,5</td>
</tr>
<tr>
<td><em>Carabids</em></td>
<td>5,5</td>
<td>7,9</td>
<td>2,6</td>
<td>3,3</td>
</tr>
<tr>
<td><em>Weevils</em></td>
<td>6,9</td>
<td>8,3</td>
<td>9,2</td>
<td>1,7</td>
</tr>
<tr>
<td><em>Other</em></td>
<td>17,1</td>
<td>12,5</td>
<td>6,9</td>
<td>4,6</td>
</tr>
<tr>
<td><em>Hymenoptera</em></td>
<td>17,1</td>
<td>55,9</td>
<td>62,6</td>
<td>30,8</td>
</tr>
<tr>
<td><em>Bumblebees</em></td>
<td>11,9</td>
<td>4,0</td>
<td>33,4</td>
<td>14,4</td>
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<tr>
<td><em>Ants</em></td>
<td>2,0</td>
<td>44,9</td>
<td>19,3</td>
<td>7,0</td>
</tr>
<tr>
<td><em>Other</em></td>
<td>3,2</td>
<td>7,1</td>
<td>10,0</td>
<td>9,4</td>
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<td>3,9</td>
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<td>13,1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>n. pellets</th>
<th>n. ind. prey</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>115</td>
<td>1381</td>
</tr>
<tr>
<td></td>
<td>35</td>
<td>864</td>
</tr>
<tr>
<td></td>
<td>63</td>
<td>629</td>
</tr>
<tr>
<td></td>
<td>52</td>
<td>458</td>
</tr>
</tbody>
</table>

**Missing link in the food web**
Red-backed shrike in coastal dunes

Life cycle Anomala dubia

Anomala 2 years (Rittershaus 1927)

- egg
- L1
- L2
- L3
- pupal
- adult

- Feb
- Mar
- Apr
- May
- Jun
- Jul
- Aug
- Sep
- Oct
- Nov
- Dec
- Jan
- Feb
- Mar
- Apr
- May
- Jun
- Jul
- Aug
- Sep
- Oct
- Nov
- Dec

- June - July
- May - June
- July - May
- 2 years
Red-backed shrike in coastal dunes

Density of larvae: intact Danish dunes

- Highest density of larvae in dynamic dunes
- High vital root biomass in dynamic dunes
Red-backed shrike in coastal dunes

Density of larvae: intact Danish dunes

Highest density of larvae in dynamic dunes

High vital root biomass in dynamic dunes

Possibly a 1-year life cycle in dynamic dunes
Red-backed shrike in coastal dunes

Use species to trace changes across the ecosystem

• increased vegetation succession
• changes in microclimate (soil fauna)
• lower heterogeneity and prey availability (carnivores)

Restore eolian activity is a promising restoration strategy
Conclusions and recommendations

How to restore degraded ecosystems?

‘Match’ between species and environment

- Species’ biology
- Environmental conditions
- Impact of degradation
- Effect of restoration
- Scale

Species biology

Match?

Scale:
- Spatial & temporal habitat use
- Spatial & temporal environmental heterogeneity

Degradation

Environment

Restoration
Conclusions and recommendations

How to restore degraded ecosystems?

Mismatch $\xrightarrow{\text{Topdown: selection}}$ Match $\xrightarrow{\text{Bottom up: aggregation}}$

Conserve and restore landscape heterogeneity

- Include different habitat types and their transitions
- Management: phased and on a small scale
- Strengthen underlying key processes
eolian activity and regional groundwater
Matching species to changing landscapes
Restoring faunal communities
Thank you for your attention!

Questions?

