Getting more out of your biodiversity data with life-history strategies: a fresh approach to causally link species and their habitat

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agriculture, nature and food quality

survival plan woodland + nature
Rewetting bog remnants
  Degradation
  Results from rewetting

Unraveling species-environment relationships
  Correlations
  Species traits

Life-history strategies
  Development
  Rationale

Applying Life-history strategies
  Field data
  Applied ecology (rewetting)

Getting more out of your biodiversity data with life-history strategies
Environment
Species
Theory
Rewetting bog remnants
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Getting more out of your biodiversity data with life-history strategies
Rewetting of bog remnants

Strongly degraded
peat cutting (desiccation, loss of area)
eutrophication (intensive agriculture, decomposition)
Peatcutting
~99% of raised bogs lost

Source: Verhoeven (ed.), 1992
Eutrophication

![Graph showing the relationship between NH4 + NO3 surface water and PO4 surface water with data points for NL and EST regions.](image)
Degradation of bog remnants

the Netherlands

Uniform landscapes lacking variation
Degradation

Intact

Degraded
Restoration measures

Retention of rainwater
Decrease drainage
Rewetting

Intact

Recovery?
Comparative studies

Degraded bog remnants (NL)
no restoration measures taken
rewetting

Pristine bog landscapes (Est)

Many different systematic groups:
- Platwormen (Tricladida)
- Bloedzuigers (Hirudinea)
- Borstelwormen (Oligochaeta)
- Waterkevers (Coleoptera)
- Waterwanten (Hemiptera)
- Libellen (Odonata)
- Haften (Ephemeroptera)
- Steenvliegen (Plecoptera)
- Dansmuggen (Diptera: Chironomidae)
- Meniscusmuggen (Diptera: Dixidae)
- Pluimmuggen (Diptera: Chaoboridae)
- Steekmuggen (Diptera: Culicidae)
- Kokerjuffers (Trichoptera)
- Waterspin (Argyroneta aquatica)
- Waterpissebed (Asellus aquaticus)
Comparative studies

Relict populations present
Case study Korenburgerveen

45 waterbodies sampled
- spring & autumn
- before and after measures took effect

209 samples
>145,000 individuals
>267 taxa
Case study Korenburgerveen
Comparative studies

More of the same after rewetting
Comparative studies

More of the same after rewetting
Rewetting bog remnants
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  Results from rewetting

**Unraveling species-environment relationships**
  Correlations
  Species traits

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Getting more out of your biodiversity data with life-history strategies
Unraveling species-environment relationships

Two approaches
  Single species - mechanistic - experiments
  Communities - descriptive - surveys

Community ecology:
  General rules to explain patterns in the distribution of species

Watt (1971):
  ‘If we do not develop a strong theoretical core that will bring all parts of ecology back together, we shall all be washed out to sea in an immense tide of unrelated information’.
Acidity: 3,9 (3,4 - 4,4)
Depth: 78 cm (39 - 140)
Size: 39 m² (2 - 190)
Nitrate: 7.6 µmol·l⁻¹ (0 - 22,5)
Shading
Substratum
Vegetation cover

* et cetera *

**Match species and environment**

**Problems**
1. Many conditions

**Species**

**Environment**

**Conditions**

**Match?**
Match species and environment

Problems
1. Many conditions
2. Many species
Higher plants ~1,400 species
Anchored species ~24,000 species
Match species and environment

Problems
1. Many conditions
2. Many species
3. Causality?

Species

Match?

Environment

conditions

Degradation

Restoration

‘changing landscapes’
Previous analyses incorporating species traits

Difficulties:

* A posteriori
  Ad hoc explanations
  Predictions performed poorly

Relationships among traits
  Averaging out
  Alternative suites

Explanation for patterns in species occurrence?

Statzner et al., 2004 Ecography 27: 470-488.
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Getting more out of your biodiversity data with life-history strategies
Life-history strategies - a fresh approach

Start from species traits

Define functionally equivalent groups *a priori* based on trait combinations

*Life-history strategies:*

“sets of co-evolved traits which enable a species to deal with a range of ecological problems.”

Stearns (1976) Quarterly Review of Biology 51: 3-47.

Test theoretically defined groups with empirical data.
Life-history strategies in aquatic macroinvertebrates

- Development
  - Morphology
  - Body size
  - Development time
  - Adult life span

- Synchronisation
  - Diapause & Quiescence

- Dispersal
  - Dimorphism
  - Active flight
  - Passive transport
  - No flight

- Reproduction
  - (Seasonal) iteroparity
  - Per capita investment
  - Egg number
  - Semelparity
Life-history strategies in aquatic macroinvertebrates

Consider multiple traits acting in concert

- Relationships among traits (trade-offs and spin-offs)
- Investment in traits
Life-history strategies in aquatic macroinvertebrates

- **Development**
  - Morphology
  - Body size
  - Development time
  - Adult life span
- **Reproduction**
  - (Seasonal) iteroparity
  - Per capita investment
  - Egg number
  - Semelparity
  - Diapause & Quiescence
  - Period & duration of synchronisation
  - Resistant stages (eggs, cocoons)
  - Feeding adults
  - Non-feeding adults
  - Density of mates
- **Synchronisation**
  - Habitat persistance
- **Dispersal**
  - Dimorphism
  - Active flight
  - Passive transport
  - No flight
  - Low genetic recombination
Life-history strategies in aquatic macroinvertebrates

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

Growth and development
Egg size and egg number
...

[Images of aquatic macroinvertebrates]
Life-history strategies in aquatic macroinvertebrates

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

Growth and development
Egg size and egg number
...

Spinn-off
Investments in one trait → increases benefits or lowers costs for another

Few eggs and brood care
Gills in damselflies for respiration and locomotion
...


Life-history strategies in aquatic macroinvertebrates

Consider multiple traits acting in concert
- Relationships among traits (trade-offs and spin-offs)
- Investment in traits

Function of traits and combinations of traits
- In light of other traits of a species
- Relative differences (similar body plan)
- Alternative suites (different body plan)
Life-history strategies in aquatic macroinvertebrates

Different traits combinations may be functionally similar
Egg protection:
- endophytical oviposition
Life-history strategies in aquatic macroinvertebrates

Different traits combinations may be functionally similar

Egg protection:
- endophytical oviposition
- gelatinous matrix
Life-history strategies in aquatic macroinvertebrates

Different traits combinations may be functionally similar

Egg protection:
- endophytyical oviposition
- gelatinous matrix
- brood care
Life-history strategies in aquatic macroinvertebrates

Different traits combinations may be functionally similar

Egg protection:
- endophytical oviposition
- gelatinous matrix
- brood care
- ovoviviparous
Life-history strategies in aquatic macroinvertebrates

Different traits combinations may be functionally similar

Egg protection:
- endophytical oviposition
- gelatinous matrix
- brood care
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Life-history strategies in aquatic macroinvertebrates

Considering multiple traits acting in concert
Function of traits and combinations of traits

13 life-history strategies
Rewetting bog remnants
  Degradation
  Results from rewetting

Unraveling species-environment relationships
  Correlations
  Species traits

Life-history strategies
  Development
  Rationale

Applying Life-history strategies
  Field data
  Applied ecology (rewetting)

Getting more out of your biodiversity data with life-history strategies
Applying life-history strategies to field data

45 waters sampled

>145,000 individuals

>267 taxa
### Applying life-history strategies to field data

#### Functional classification spanning different systematic groups

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Habitat suitability as a key aspect

High investments in physiological tolerance, constraining other investments

Bog pools (n=18)

large bog pools (6)
small bog pools (6)
small, shaded bog puddles (6)

Habitat suitability as a key aspect
Habitat suitability as a key aspect

Bog pools (n=18)

- large bog pools (6)
- small bog pools (6)
- small, shaded bog puddles (6)

High investments in physiological tolerance, constraining other investments

Habitat suitability as a key aspect
Habitat suitability as a key aspect
Differences in abundance aggregated
Mesotrophic waters (n=14)

- shallow mesotrophic puddles (4)
- mesotrophic pools (5)
- strongly buffered mesotrophic pools (5)
High investments in physiological tolerance, constraining other investments

Long larval development with synchronised emergence of short-lived adults

High per capita investment and several successive reproduction events

Mesotrophic waters (n=14)

- shallow mesotrophic puddles (4)
- mesotrophic pools (5)
- strongly buffered mesotrophic pools (5)

Predictability and stability as a key aspect
Evaluating the effects of rewetting measures

Rewetting
Increase retention of rainwater
Decrease drainage
Evaluating the effects of rewetting measures

Water bodies in forest

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

More variable and unpredictable environment
Evaluating the effects of rewetting measures

More groundwater influence cyclic, predictable environment
Evaluating the effects of rewetting measures

Risk spreaders
Stress tolerators
Synchronisers

Life-history strategy

Abundance (%)

Before measures
After measures

2- T1,R1+R3
2+ S1,S2,S3 + S4

p=0.97
Evaluating the effects of rewetting measures

Bog pools

- Higher water table
- Stagnation
- Less groundwater

More harsh and constant environment
Evaluating the effects of rewetting measures

Bog pools

Not a harsher environment
Evaluating the effects of rewetting measures

Stress tolerators Synchronisers

Life-history strategy
Evaluating the effects of rewetting measures

Life-history strategy

Risk spreaders
Stress tolerators
Synchronisers

Stress tolerators
Synchronisers

Abundance (%) before and after measures

Legend:
- Before measures
- After measures

Figure a:
- Risk spreaders: T1, R1+R3
- Stress tolerators: S1, S2, S3 + S4
- Synchronisers

Figure b:
- Stress tolerators: T1
- Synchronisers: S1+S2

Statistical significance:
- *: Significant difference
- n.s.: Not significant

p-value:
- p=0.97
Evaluating the effects of rewetting measures

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 promising restoration strategy
Rewetting bog remnants
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Life-history strategies
   Development
   Rationale

Applying Life-history strategies
   Field data
   Fundamental ecology (abundance-occupancy relationships)
   Applied ecology (rewetting)

Getting more out of your biodiversity data with life-history strategies
Problems
1. Many conditions
2. Many species
3. Causality?

Life-history strategies
1. Integrated response
2. Group species
3. Explain and predict

Causality
Aggregation

Community ecology: underlying mechanisms

Restoration ecology: functionally complete
## Getting more out of your biodiversity data

**Single species - mechanisms - experiments**  
**Communities - descriptions - surveys**

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<tr>
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<th>Community approach</th>
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<tr>
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### Diagrams

**Species approach**

```
Species assemblage
  B
  A
  C
  D
  E
```

**Community approach**

```
Species assemblage
```

- Richness
- Diversity
- Evenness
- Rank abundance
- Abundance - occupancy
- ...

Black box

Species assemblage
Getting more out of your biodiversity data

Single species - mechanisms - experiments
Communities - descriptions - surveys

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Life-history strategies
1. Integrated response
2. Group species
3. Explain and predict

Species assemblage

Black box
Getting more out of your biodiversity data

Single species - mechanisms - experiments
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## Diagram

### Species approach
- **Suitability**
- **Connectivity**

### LH strategy approach
- **Suitability**
- **Connectivity**

### Community approach
- **Suitability**
- **Connectivity**

> Richness
> Diversity
> Eveness
> Rank abundance
> Abundance -occupancy
> ...

Black box

Species assemblage

Species assemblage

Species assemblage
Thank you for your attention!


http://webdoc.ubn.ru.nl/mono/v/verberk_w/matcsptoa.pdf

w.verberk@science.ru.nl