Body size and dispersal mode as key traits determining metacommunity structure of aquatic organisms
Spatial dynamics in community ecology

Metacommunities: local communities that are linked with each other through dispersal of multiple potentially interacting species

Leibold et al. 2004
Holyoak et al. 2005
Major community perspectives

- **Niche perspective**: compositional variation among communities is structured mainly by the interaction of species’ niches with the environment and the composition of a community is shaped by the process of species sorting (Leibold et al. 2004).

- **Neutral perspective**: Species and habitat patches can be considered equal and variation in the composition among communities is generated by neutral dynamics, such as drift, local stochastic extinctions, immigration and emigration (Hubbell 2001).
Dispersal as driving force of metacommunity structure

Neutral perspective

- Dispersal limitation allows spatial patterns in metacommunities to be generated by drift and stochastic colonisation

- Dispersal homogenizes metacommunities

DISPERSAL

Limiting

Non-limiting

Massively

Niche perspective
Dispersal as driving force of metacommunity structure

Neutral perspective

- Dispersal limitation allows spatial patterns in metacommunities to be generated by drift and stochastic colonisation

- Dispersal homogenizes metacommunities

Niche perspective

- Efficient species sorting, leading to a good match between community composition and the environment
Dispersal limitation constrains species sorting, leading to a poor match between community composition and the environment.

Predominance neutral patterns.

Efficient species sorting, leading to a good match between community composition and the environment.

Dispersal limitation allows spatial patterns in metacommunities to be generated by drift and stochastic colonisation.

Dispersal homogenizes metacommunities.

- Neutral perspective
- Niche perspective

Dispersal as driving force of metacommunity structure.
Dispersal as driving force of metacommunity structure

Neutral perspective

- Dispersal limitation allows spatial patterns in meta-communities to be generated by drift and stochastic colonisation
- Dispersal homogenizes metacommunities

Niche perspective

- Dispersal limitation constrains species sorting, leading to a poor match between community composition and the environment
- Predominance neutral patterns

Dispersal as driving force of metacommunity structure

Limiting

Non-limiting

Massively

- Efficient species sorting, leading to a good match between community composition and the environment
- Communities are quantitatively affected by dispersal from source into sink habitats, leading to a poor match between community composition and the environment
The method of variation partitioning

Total amount of community variation
Explained by environmental model
Explained by spatial model
Result of variation partitioning

Unexplained
S/E
E&S
E/S
Use of variation partitioning results to infer metacommunity processes

Purely environmental \([E/S]\) 
\[\begin{array}{c}
\text{not significant} \\
\text{significant} \\
\end{array}\] 

Purely spatial \([S/E]\) 
\[\begin{array}{c}
\text{not significant} \\
\text{significant} \\
\end{array}\] 

\[\text{Dispersal limitation}\]

\[\text{Species sorting}\]

\[\text{Species sorting constrained by dispersal limitation}\]
Metacommunity structure will depend on the interaction of organism traits and landscape connectivity

(1) Prediction for **passive** dispersers:
signature of dispersal limitation will increase with body size

- Larger propagules > lower dispersal distances
- Smaller populations > production of lower amounts of propagules
  > more prone to local extinction

Debain et al. 2003
Hillebrand 2001
Finlay et al. 2002
Shurin et al. 2009
Ptacnik et al. 2010
Characteristics of the organism

(1) Prediction for passive dispersers:
   signature of dispersal limitation will increase with body size

(2) Prediction for active dispersers:
   signature of dispersal limitation will decrease with body size
Characteristics of the organism

(1) Prediction for passive dispersers:
signature of dispersal limitation will increase with body size

(2) Prediction for active dispersers:
signature of dispersal limitation will decrease with body size

(3) Active dispersers more or less dispersal-limited than passive dispersers?

- Higher dispersal abilities (?)
- Active habitat choice
- But smaller populations
Metacommunity structure, body size and dispersal mode

12 different organism groups
Metacommunity structure, body size and dispersal mode

Variation partitioning of RDA-models
Metacommunity structure, body size and dispersal mode

Variation partitioning of RDA-models

![Graph showing explained variation in body size and dispersal mode across different log mean body sizes.]
Metacommunity structure, body size and dispersal mode

Variation partitioning of RDA-models

![Graph showing variation partitioning of RDA-models with explained variation (%), log mean body size (µm), and categories of passive and active dispersers for vertebrates and flying insects.]
Metacommunity structure, body size and dispersal mode

Variation partitioning of RDA-models

- **Passive dispersers**
- **Active dispersers**

![Diagram showing explained variation (%)](image-url)
Variation partitioning on RDA-models: environment versus space

Metacommunity structure and dispersal mode
Metacommunity structure and dispersal mode

Detection of influential spatial scales

Result of variation partitioning

- Unexplained
- S/E
- E&S
- E/S

construction of spatial model through construction of Moran Eigenvector Maps (MEM-analysis)

- Fine-scale
- Medium-scale
- Broad-scale
Detection of influential spatial scales

Metacommunity structure, body size and dispersal mode

- Passive dispersers
- Actively flying dispersers
- Amphibians
- Fish

Relative contribution to S/E (%)
Conclusions:

We observed strong and consistent relationships between key traits of organism groups and the structure of their metacommunities.

+ **passive dispersers**: dispersal limitation increases with body size
  increasing strength of spatial patterns
  decreasing spatial scale at which patterns are manifested

+ **active dispersers**:
  - **flying insects** tend to be less dispersal limited than passive dispersers of similar body size
  - **amphibians** and **fish**: small-scale spatial patterns suggest strong reliance on local connectivity patterns
Conclusions:

With increasing spatial scale, beta diversity tends to shift from being environmentally controlled to being dispersal-controlled.

Our results show that the scale at which this shift occurs depends on organism traits, such as body size and dispersal mode.

Incorporation of traits can therefore
- provide a more predictive framework for metacommunity ecology
- help steer management decisions (e.g., identification of groups vulnerable to dispersal limitation)
Metacommunities of macrophytes and zooplankton in ditch systems of The Netherlands

NWO ‘Biodiversiteit werkt’-project
Study of link between spatial community patterning and dispersal traits in macrophytes
The MANSCAPE consortium

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