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WHEN THE RIVERS RUN DRY: EFFECTS ON INVERTEBRATE COMMUNITIES AND THE DYNAMIC OF PARTICULATE ORGANIC MATTER

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Doctoral school E2M2
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Agenda of the presentation

1. Generalities, conceptual framework and objectives
2. Sampling sites and techniques
3. Terrestrial invertebrate communities
4. Particulate organic matter decomposition
5. A rewetting event
6. Synthesis, discussion and perspectives
The ecotone concept and aquatic-terrestrial transitions
The concept of **ecotone**

A *transition zone* between two ecosystems
The concept of ecotone

**Edge effect**: an ecotone harbors species from the adjacent ecosystems and species specific to the transition zone

Four main **functions** of an ecotone

*From Kolasa & Zalewski, 1995*
Aquatic-terrestrial transitions

Rivers are dynamic ecosystems with contraction and expansion cycles.

Habitats alternate between terrestrial and aquatic conditions.

From Stanley et al., 1997
The flood pulse concept (FPC)

The FPC (Junk et al. 1989) models the interactions between aquatic and terrestrial ecosystems in the transition zone.

Aquatic and terrestrial species use the same habitats at different times.
Aquatic-terrestrial interactions

Aquatic and terrestrial **food webs** are interdependent

*Baxter et al., 2005*
Temporary rivers

Widespread and abundant ecosystems

25 to 40% of French rivers are temporary

Increasing tendency

Snelder et al., 2013
A shifting habitat **mosaic**
Aquatic biodiversity in temporary rivers

Flow intermittence – biodiversity relationships

Communities in temporary rivers are nested subsets of those in perennial rivers

Datry et al., submitted
Terrestrial biodiversity in temporary rivers

Dry riverbeds have been neglected by aquatic and terrestrial ecologists

Lack of standardized and tested sampling methods

Riparian zones are sources of colonists
Dry riverbeds are harsh habitats

Different ecological successions?

Riparian invertebrates depend on water resource and aquatic preys

What is the effect of river drying on riparian invertebrates?
Decomposition of particulate organic matter

Transport, storage and decomposition of organic matter are fundamental processes in rivers

Decomposition through the action of shredders and micro-organisms

Current models and concepts do not apply to temporary rivers

Discontinuities
Key objectives

1. Compare 2 common sampling methods for collecting terrestrial invertebrates in dry riverbeds

2. Characterize terrestrial invertebrate communities in dry riverbeds

3. Specify the effect of river drying on riparian invertebrate communities

4. Address the role of drying events on the decomposition of particulate organic matter

5. Characterize the fluxes of invertebrates and organic matter in an advancing wetted front
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Methods

A multi-site and comparative approach

Sampling sites & techniques
Studied sites

4 gravel-bed temporary rivers in contrasted climates of France and New-Zealand
Studied sites

- Albarine
- Asse
- Selwyn River
- Lower Farm Stream
Hydrological characteristics

Contrasted patterns and longitudinal gradients in flow intermittence

Larned et al., 2011
Sampling techniques

2 sampling techniques for terrestrial invertebrates

1 sampling technique for the decomposition of organic matter

1 sampling technique for invertebrates and organic matter in transitional habitats
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3 Terrestrial invertebrate communities in temporary rivers

3.1 Comparison of pitfall-trap and quadrat methods

3.2 Colonization of dry riverbeds

3.3 River drying and riparian invertebrate communities
Pitfall traps accumulated more taxa than quadrats and more rapidly.

Communities in quadrats were subsets of those in pitfall traps.

Pitfall trapping is the most efficient method.

8 to 11 pitfall-traps / 100 m² = 80% of the taxonomic richness.
Terrestrial invertebrate communities in temporary rivers

3.1 Comparison of pitfall-trap and quadrat methods

3.2 Colonization of dry riverbeds

3.3 River drying and riparian invertebrate communities
### Sampling design

#### Albarine
- 4 temporary sites
- 3 perennial sites
- 3 transects / site
- 7 pitfall traps / transect
- 2 sampling dates before the dry period
- 2 sampling dates during the dry period

#### Asse
- 1 temporary site
- 7 transects / site
- 6 to 7 pitfall traps / transect
- 3 sampling dates before the dry period
- 2 sampling dates during the dry period

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**Albarine River**

[Map of Albarine River showing temporary and perennial sections]

**Perennial section**

**Temporary section**

[Diagram of transect design with transect length = 2 x wetted channel, showing 3 m, 0.5 m, and 3 m intervals]

**River bed (15 m)**

**Active channel (18 m)**

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**Note:** The map and diagram illustrate the sampling design for both Albarine and Asse rivers, highlighting the number of sites, transects, pitfall traps, and sampling dates specified for each section.
Taxa identification

Most of Coleoptera, Araneae and Formicidae were identified to species or genus level

Other taxa were identified to family, order or class

All arthropods were assigned to feeding guilds (predators, herbivors, and detritivors)

Araneae, Carabidae and Formicidae species were characterized according to their moisture preferences (Hygrophilous species)
3.2 Terrestrial invertebrates

Data from temporary sites of the Albarine and Asse rivers
298 taxa: 241 taxa in the Albarine River and 84 in the Asse River

Most abundant taxa

**Albarine**

*Oniscidae, Aleocharinae (Staphylinidae), Myrmica rubra (Formicidae), Opiliones*

**Asse**

*Labidura riparia (Dermaptera), Pardosa wagleri (Araneae), Formica selisy (Formicidae),*
Riparian zones vs dry riverbeds

Corti et al., in prep

Higher taxonomic richness in riparian zones compared to dry riverbeds in the Albarine River

Consistent patterns in sites and rivers
Riparian zones vs dry riverbeds

Dry riverbed communities were *subsets* of those in riparian zone (Adonis, $R^2 < 0.1$, $p < 0.05$ for all sites)

- More predators in dry riverbeds

*Corti et al., in prep*
Colonization of dry riverbeds

The colonization of dry riverbeds likely follows a source-sink dynamic with density-dependence mechanisms.

Absence of ecological successions.
Terrestrial invertebrate communities in temporary rivers

3.1 Comparison of pitfall-trap and quadrat methods

3.2 Colonization of dry riverbeds

3.3 River drying and riparian invertebrate communities
Effect of drying on community structure

Data from temporary and perennial sites of the Albarine River

Corti et al., in prep

1.5-fold decrease in taxonomic richness at both temporary and perennial sites

Activity patterns of invertebrates are synchronized with the summer drying period
Effect of drying on community composition

Procruste analysis

Separation of temporary and perennial sites was more pronounced during the dry period compared to before

Recolonization of temporary sites during flowing periods

Corti & Datry, in prep
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Particulate organic matter (POM) decomposition in temporary rivers

Effects of drying-rewetting cycles
Sampling design

6 pools with contrasted drying-rewetting cycles in the Selwyn River

Corti et al. 2011, Aquatic Sciences

30-day experiment
Estimation of microbial activity using FDA
Identification of aquatic and terrestrial invertebrates
POM decomposition in the habitat mosaic

Corti et al. 2011, Aquatic Sciences

Fastest decomposition on immersed conditions

Drying-rewetting cycles have strong effects on POM decomposition

Decomposition is highly heterogeneous in the habitat mosaic
Effect of drying-rewetting cycles

Quantitative relationships are crucial ...

... to compare and predict the influence of drying-rewetting cycles and to manage river hydrology

Decomposition rate (k) varied with cumulative emersion duration

Corti et al. 2011, Aquatic Sciences
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A rewetting event

Invertebrates and particulate organic matter in a rewetting front
Objectives

Rewetting fronts in the Albarine river

Corti & Datry, 2012, Freshwater Science

Characterize the composition of a rewetting front in invertebrates and particulate organic matter
Examine the longitudinal distribution of communities and particulate organic matter along a rewetting front
Method

11 rewetted sites and 3 perennial sites in the Albarine River

Alive and dead terrestrial invertebrates were sorted on the field
Rewetting fronts entrained large quantities of terrestrial invertebrates and organic matter

A **longitudinal pulse** analogous to lateral flood pulses observed in large perennial rivers

Positive and negative consequences

*Corti & Datry, 2012, Freshwater Science*
1. Results

Rewetting fronts are a **dispersal mechanism** for some dry riverbed invertebrates

- Riparian zones are refuges
- Invertebrate successions in riparian zones?

24/70 alive taxa

*Corti & Datry, 2012, Freshwater Science*

Intermediate zones of deposition and accumulation
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Synthesis and perspectives
Terrestrial invertebrates account for a large part of invertebrate biodiversity in temporary rivers

- 2-4 times more terrestrial taxa

No specific taxa = No edge effect

The dynamic of terrestrial communities differs from the dynamic of aquatic communities

- Aquatic = longitudinal dispersion
- Terrestrial = lateral dispersion
- Nestedness
Dynamic of organic matter in temporary rivers

Drying events influence the transport, accumulation and decomposition of organic matter

**Nutrient spiraling concept**

From Newbold et al., 1981

Uptake and turnover depend on the dry period duration

Decomposition, accumulation and transport of particulate organic matter is longitudinal and punctuated in temporary rivers
Managing dry riverbeds

Monitoring sites as for aquatic invertebrates?

Is there a link between human impacts and terrestrial communities?

Riparian zones harbor specific communities

20% of gravel-bar carabidae are endangered species

Management of riparian zones needs to be expand to dry riverbeds
Synthesis and perspectives
**Terrestrial invertebrate dispersal**

Are rewetting events important pathways for the dispersal of riparian invertebrates?

- A metapopulation approach
- Capture-Mark-recapture

**Aquatic-terrestrial interactions**

How trophic regimes of terrestrial invertebrates change during dry periods in temporary rivers?

- Analysis of stable isotopes
Organic matter in river networks

Rivers are responsible of a large amount of CO$_2$ outgassing to the atmosphere (Battin et al. 2009)

What is the role of temporary rivers in controlling Carbon (C) fluxes in river networks?

Measuring and modeling import, export and decomposition rates of organic matter
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