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28th International Scientific Conference

Macroinvertebrate metacommunity in Mediterranean mountain ponds (South Spain)

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Universidad de Jaén

INTRODUCTION

Small water bodies

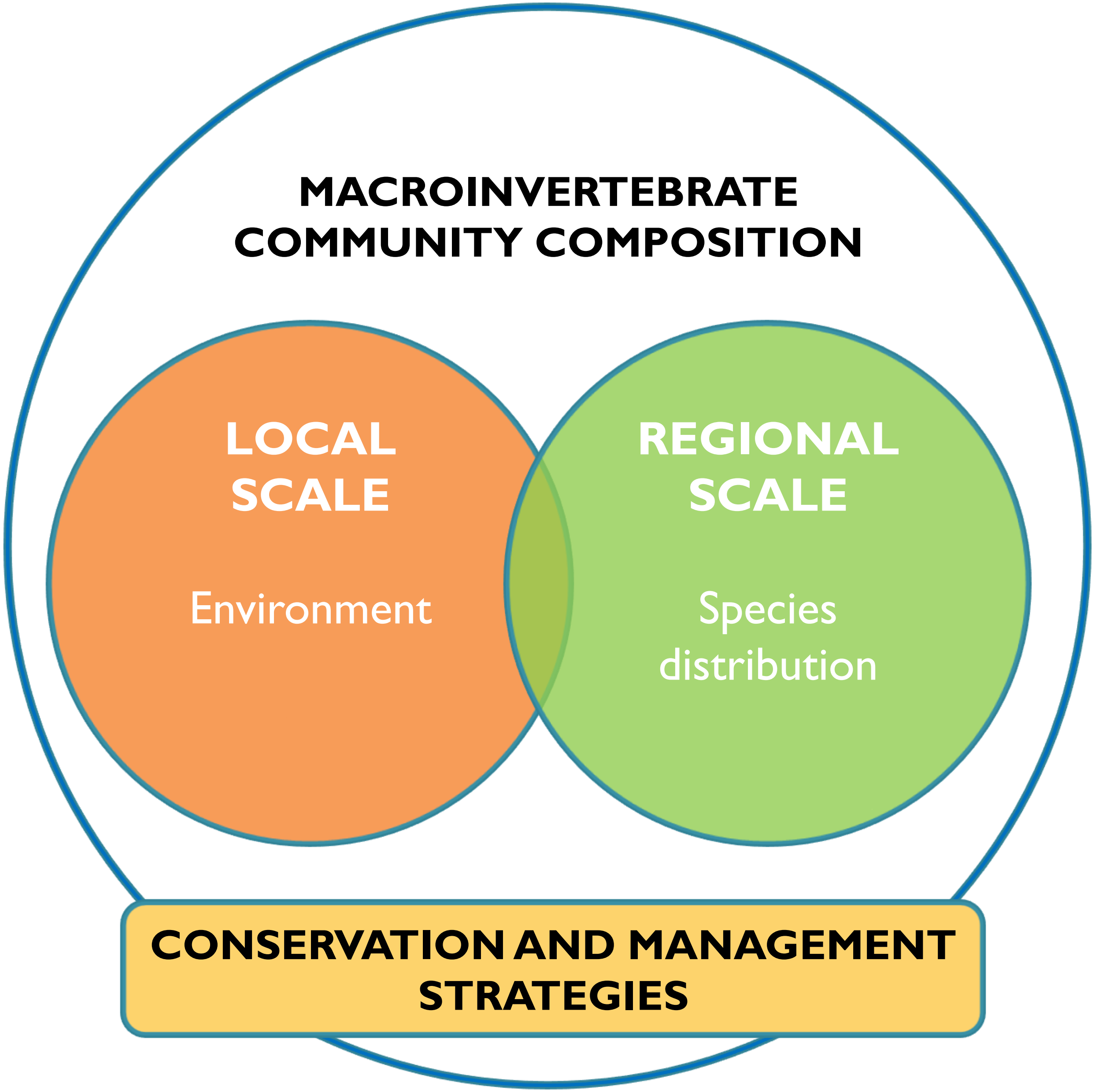
High production
High habitat heterogeneity
High biological diversity
High environmental value (ecosystems services)

Isolated habitats inside a matrix of land

Human pressures → Degradation

MEDITERRANEAN MOUNTAIN PONDS

INTRODUCTION



MACROINVERTEBRATE COMMUNITY COMPOSITION

LOCAL SCALE

Environment

REGIONAL SCALE

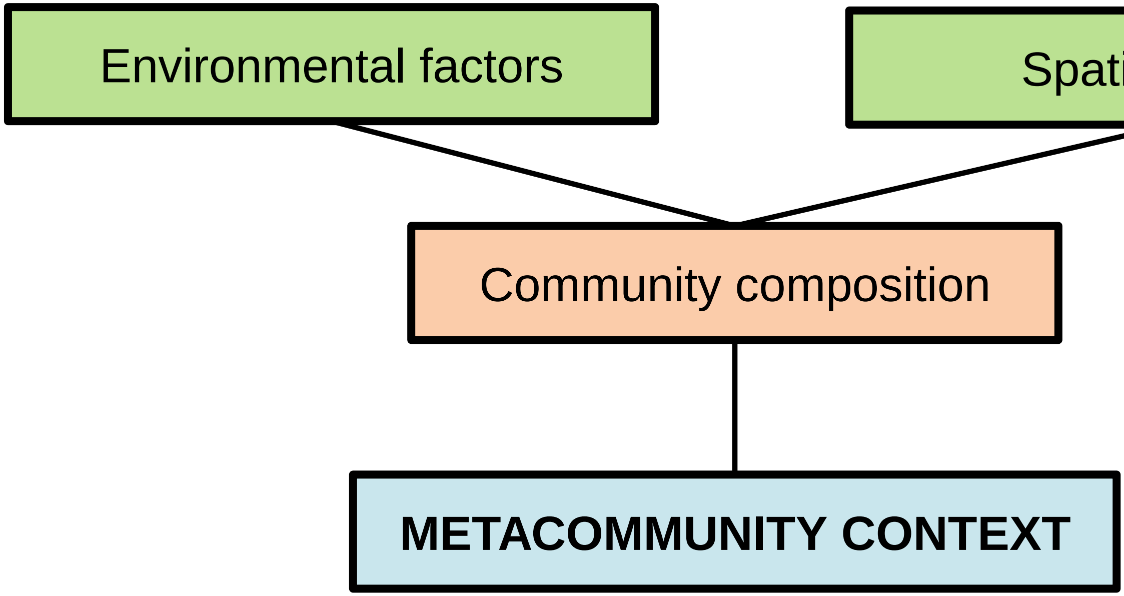
Species distribution

CONSERVATION AND MANAGEMENT STRATEGIES

AIM

HYPOTHESIS

Macroinvertebrate metacommunity of Mediterranean mountain ponds is a suitable element with implications in diversity maintenance and a key element to put forward wetlands conservation actions.



Environmental factors

Spatial factors

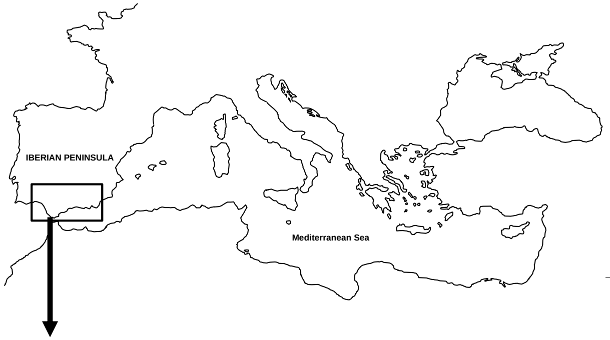
Community composition

METACOMMUNITY CONTEXT

MATERIALS AND METHODS

STUDY AREA

23 Mountain ponds Baetic Mountains
Altitude: 387-2068 m.a.s.l
Mediterranean climate: hydroperiod



Nie można wyświetlić obrazu. Na komputerze może brakować pamięci do otwarcia obrazu lub obraz może być uszkodzony. Uruchom ponownie komputer, a następnie otwórz plik pon

Studied mountain ponds in the Baetic Mountains

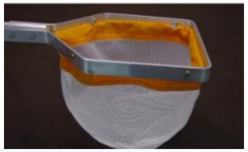
MATERIALS AND METHODS

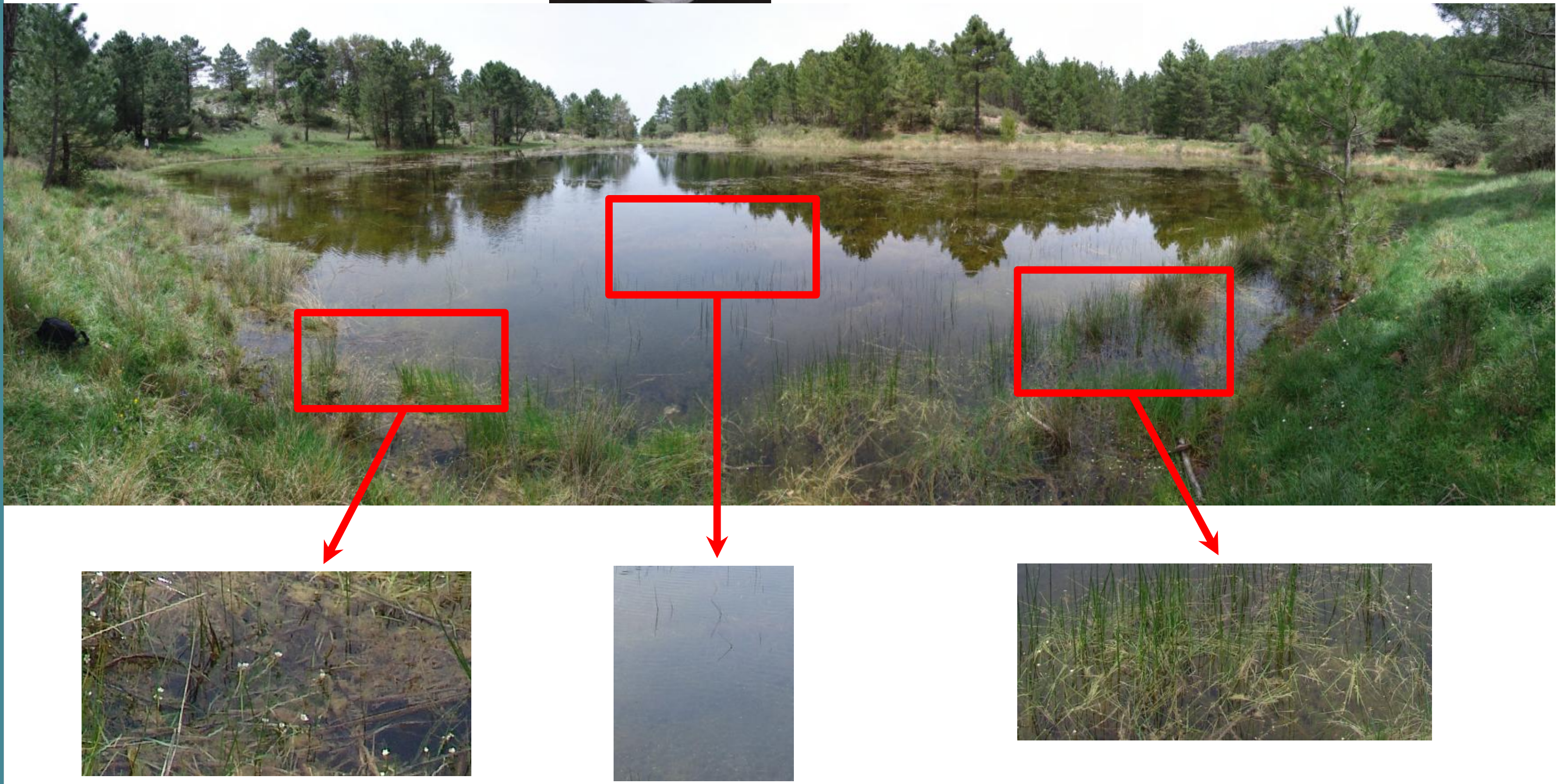
Macroinvertebrates samples

Spring 2017. Most ponds were dried

Sampling time:
>50 m^2: 3 minutes
<50m^2 30s per each 10m^2

Hand net (250 µm)



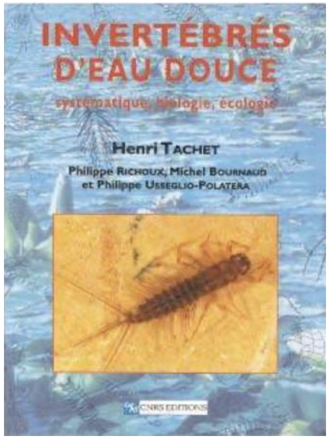


Sediments

Open water

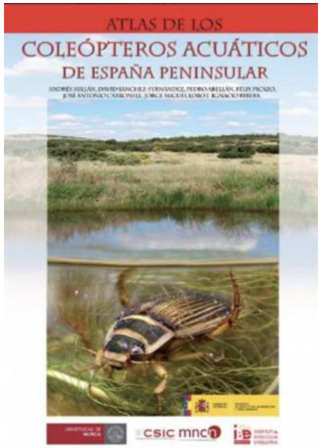
Submerged-emerged vegetation

MATERIALS AND METHODS



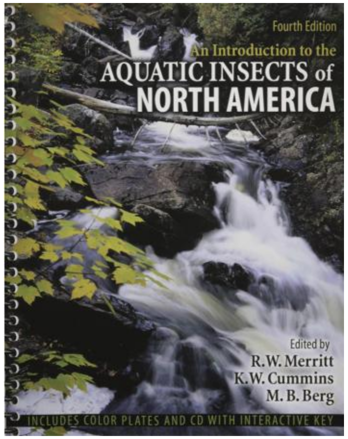
INVERTÉBRÉS D'EAU DOUCE
systématique, biologie, écologie
Henri Tachet
Philippe Richoux, Michel Bournaud et Philippe Usseglio-Polatera
CNRS EDITIONS

Tachet *et al.*, 2010



ATLAS DE LOS
COLEÓPTEROS ACUÁTICOS
DE ESPAÑA PENINSULAR

Millán-Sánchez *et al.*, 2014



Fourth Edition
An Introduction to the
AQUATIC INSECTS of
NORTH AMERICA
Edited by
R.W. Merritt
K.W. Cummins
M.B. Berg
INCLUDES COLOR PLATES AND CD WITH INTERACTIVE KEY

Merrit *et al.*, 2008

Clé de détermination des
Exuvies des Odonates
de France
Guillaume DOUCET
3e édition
Société Française d'Odonatologie
Fondation Nature & Découvertes

Doucet, 2016

MATERIALS AND METHODS

Environmental variables

Water temperature and conductivity

Turbidity

Depth and pond size

Altitude

Substrate typology

Isolation

Hydroperiod

Nutrients: TP and TN

MATERIALS AND METHODS

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Data analysis

Elements of Metacommunity Structure EMS

COHERENCE

- NS +

Checkerboard
Random
TURNOVER

- NS +

Nested subsets
Quasi-structure
BOUNDARY CLUMPING

I < 1
NS
I > 1

Evenly spaced
Gleasonian
Clementsian

Software notes

Ecography 37: 402–405, 2014
doi: 10.1111/j.1600-0587.2013.00695.x

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metacom: an R package for the analysis of metacommunity structure

Tad Dallas

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Metacommunity theory is an extension of metapopulation theory with the goal of understanding how ecological communities vary through space and time. One off-shoot of metacommunity theory deals with understanding how community structure varies along biotic or environmental gradients. The Elements of Metacommunity Structure framework is a three-tiered analysis of metacommunity structure that enables the user to identify metacommunity properties that arise in site-by-species incidence matrices. These properties can then be related to underlying variables that influence species distributions. The EMS framework is now implemented in metacom, an open source R package that allows for the analysis and plotting of metacommunities.

Metacommunity theory is an attempt to identify the mechanisms underlying species distributions as they relate to community structure, a central focus of community ecology (Holyoak et al. 2005, Soininen et al. 2007, De Meester 2011). The framework proposed by Leibold and Mikkelson (2002), and later expanded by Presley (2010), offers an approach to determine metacommunity 'pattern', and the environmental or spatial variables underlying this structure. The Elements of Metacommunity Structure (EMS) framework is based on the evaluation of three metrics calculated from a presence–absence interaction matrix, with sites as rows and species occurrences at sites as columns. To determine the metacommunity structure, the interaction matrix is ordinated via reciprocal averaging, a method that groups interactions along the matrix diagonal in a fashion that results in species with similar ranges and sites with similar species compositions to be placed together (Gauch 1982). The weights (or 'scores') obtained from ordination then represent a structuring gradient, which can then be related to environmental or spatial variables (Presley and Willig 2010). The three metrics of the EMS framework are coherence, turnover, and boundary clumping (Leibold and Mikkelson 2002), which can be visualized in three-dimensional space (Fig. 1).

Coherence is measured by counting the number of embedded absences in the ordinated matrix. Statistical significance of coherence is determined by comparing the observed absences to the number of embedded absences observed in many randomized null matrices using a z-test. Many different randomization algorithms exist (Gotelli and Graves 1996), but the best performing algorithms typically hold row (site) totals constant, and either fill occurrences among sites probabilistically based on the marginal column totals (fixed-proportional null) or by maintaining column sums (fixed-fixed null) (Ulrich and Gotelli 2007). To qualify for further analysis, community matrices must contain statistically significantly fewer embedded absences than expected under null models. Negative community matrix coherence (more embedded absences than expected under null model) indicates a checkerboard pattern, in which species occurrences among sites are mutually exclusive. Positive coherence indicates that species ranges have fewer embedded absences than expected under null model simulations, which allows for subsequent analysis of turnover and boundary clumping.

Turnover is quantified by calculating the number of times one species replaced another between sites, after species distributions are made completely coherent. Therefore, this does not include gaps within species ranges, instead considering only instances where species replace each other from site to site. This metric is compared to the distribution of turnover values obtained through many ordinated null simulations using a z-test. Low turnover is indicative of nested subsets, whereas significantly high turnover is associated with an environmentally-driven community structure (Leibold and Mikkelson 2002). Boundary clumping is quantified using the Morisita's index, a measure of the dispersion of species occurrences among sites (Morisita 1971). A Morisita's index (I) of one indicates boundaries are not clumped, while values greater than one ($I > 1.0$) or less than one ($I < 1.0$) indicate clumped or hyperdispersed boundaries, respectively. Statistical significance of the Morisita's index is determined using a chi-squared test.

MATERIALS AND METHODS

Data analysis

RDA analysis and variation partitioning analysis

Oecologia (2017) 183:121–137
DOI 10.1007/s00442-016-3750-y

CrossMark

COMMUNITY ECOLOGY – ORIGINAL RESEARCH

Metacommunity ecology meets biogeography: effects of geographical region, spatial dynamics and environmental filtering on community structure in aquatic organisms

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Risto Virtanen[6,7,8]

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Abstract Metacommunity patterns and underlying processes in aquatic organisms have typically been studied within a drainage basin. We examined variation in the composition of six freshwater organismal groups across various drainage basins in Finland. We first modelled spatial structures within each drainage basin using Moran eigenvector maps. Second, we partitioned variation in community structure among three groups of predictors using constrained ordination: (1) local environmental variables, (2) spatial variables, and (3) dummy variable drainage basin identity. Third, we examined turnover and nestedness components of multiple-site beta diversity, and tested the best fit patterns of our datasets using the "elements of metacommunity structure" analysis. Our results showed that basin identity and local environmental variables were significant predictors of community structure, whereas within-basin spatial effects were typically negligible. In half of the organismal groups (diatoms, bryophytes, zooplankton), basin identity was a slightly better predictor of community structure than local environmental variables, whereas the opposite was true for the remaining three organismal groups (insects, macrophytes, fish). Both pure basin and local environmental fractions were, however, significant after accounting for the effects of the other predictor variable sets. All organismal groups exhibited high levels of beta diversity, which was mostly attributable to the turnover component. Our results showed consistent Clementsian-type metacommunity structures, suggesting that subgroups of species responded similarly to environmental factors or drainage basin limits. We conclude that aquatic communities across large scales are mostly determined by environmental and basin effects, which leads to high beta diversity and prevalence of Clementsian community types.

Keywords Bryophytes · Diatoms · Fish · Invertebrates · Lakes · Macrophytes · Metacommunities · Streams

Introduction

Biogeography and community ecology are two disciplines that combine history, dispersal, biotic interactions and environmental filtering as determinants of the structure of biotic assemblages. However, a better understanding of the determinants of biotic assemblages might benefit from a closer conceptual unification of these disciplines (Jenkins and

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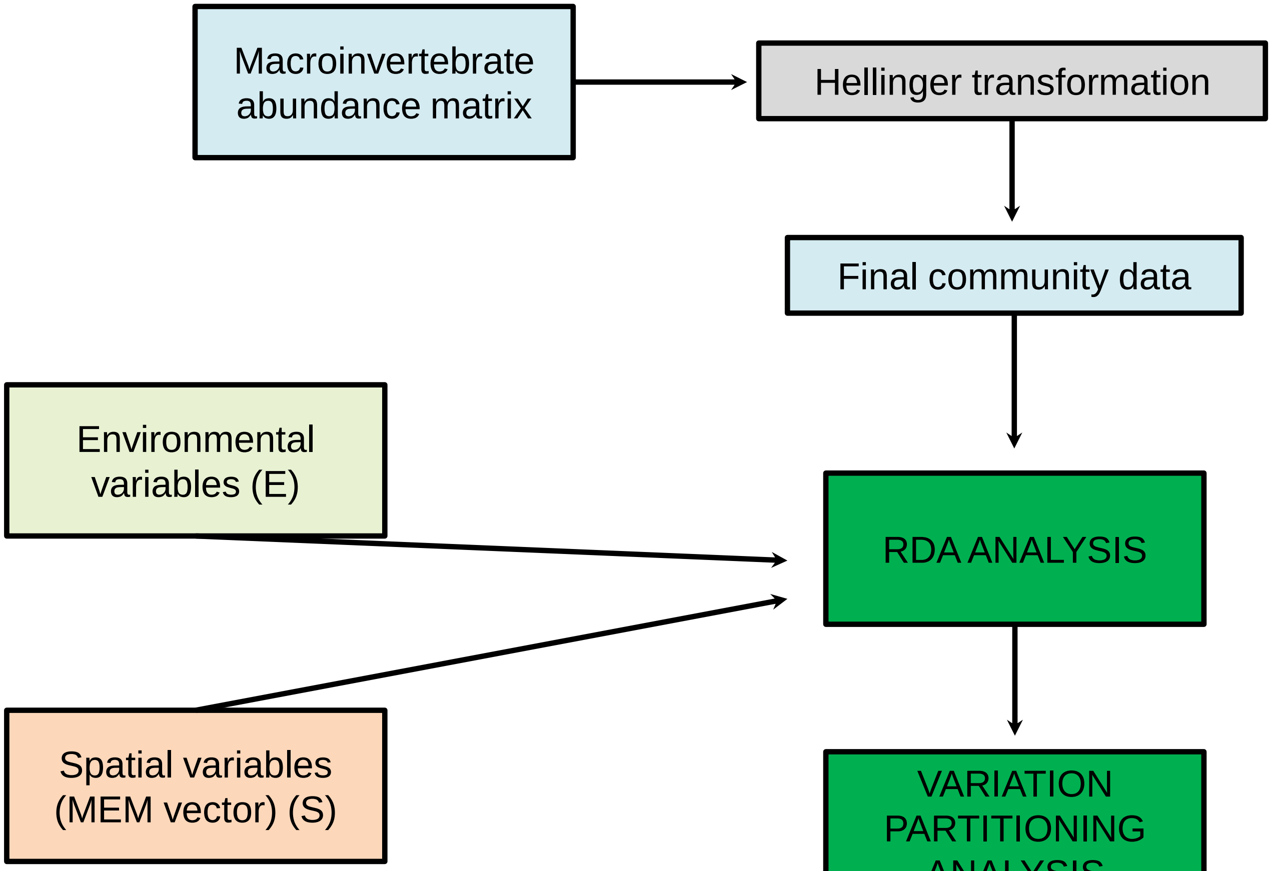
Springer



Macroinvertebrate abundance matrix

Hellinger transformation

Final community data

Environmental variables (E)

Spatial variables (MEM vector) (S)

RDA ANALYSIS

VARIATION PARTITIONING ANALYSIS

RESULTS

	Conductivity (mS/cm)	Turbidity (FTU) (FTU)	Total nitrogen	Total phosphorous	Elevation (m.a.s.l)	Hydroperiod	Size	Deep	Subst	Isolation
Laguna del Picacho del Algibe	0.21	6.94	2.01	147.23	538	T	2026.4	1.5	S	0.82
Charca de los Llanosde Líbar	0.58	3.58	0.32	62.73	970	P	380.65	3	L	0.75
Laguna de Coripe	0.62	45.33	4.85	391.87	406	T	17908.9	2	T	0.86
Laguna de Caja	0.86	137	2.31	263.55	729	T	59161.2	3	T	0.57
Laguna del Hondonero	0.33	3.9	0.57	19.95	1162	T	913.68	0.75	L	0.06
Charca Loma León	0.94	3.76	0.37	16.3	387	T	551.17	2.5	T	**0.67**
Laguna Chica	10.4	1.93	1.82	25.69	794	P	67113.5	5	T	0.04
Charco del Nevazo Largo	0.15	2.36	0.84	22.56	1347	T	2336.88	1	L	0.16
Laguna del Rico	0.34	8.17	3.08	2428.83	896	P	5752.28	2.5	L	0.65
Charca de Juan Ramos	0.29	3.51	2.57	80.46	1317	P	17.34	0.4	L	0.91
Balsa del Almiar	0.11	5.46	0.48	53.34	1775	P	1197.69	1.5	S	0.78
Manantial de la Cuerda del Alguacil	0.03	1.63	0.45	77.59	2068	T	22.74	0.2	S	0.85
Balsa Sabinar	0.12	23.27	1.01	110.71	1830	T	4787.22	2.5	L	0.54
Balsa Barjalí	0.13	61	1.55	175.4	1713	T	4084.82	1.5	L	0.42
Balsa Calabrial	0.28	67	0.52	45.51	1340	P	1513.04	2.5	L	0.69
Charca Filabres	0.18	72	8.82	712.67	1050	T	180.06	0.5	S	0.88
Charca de Balax	0.07	3.73	1.2	37.17	1892	P	51.81	0.6	S	0.68
Balsa Pocico	1.56	2.6	0.73	13.17	1275	P	283.71	1.25	L	0.74
Charca de la Franciscuela	0.31	1.54	0.26	12.13	1340	P	265.15	2	L	0.87
Laguna de Castril	0.28	>1000	28.54	3310.38	1967	T	959.03	0.5	L	0.9
Charco de la Tiná de las Cruces	0.42	41.27	1.94	104.46	1661	P	229.71	2	L	0.82
Laguna de Orcera	0.35	8.09	4.02	110.45	1264	T	4669.39	2	L	0.82
Laguna de Siles	0.25	6.5	0.54	14.21	1288	T	4406.9	2.75	L	0.85

Conductivity: 0.07 - 10.4 mS/cm

Turbidity: 1.54 - 1000 FTU

Total Nitrogen: 0.26 - 28.54 mg/L

Total Phosphorus: 12.12 - 3310.38 μg/L

Substrate: limestone (60.8%) - siliceous (17.4%)

RESULTS

50 taxa

Heteroptera – 95%

Chironomidae – 87%

Coleoptera – 78.3%

Ephemeroptera – 73.9%

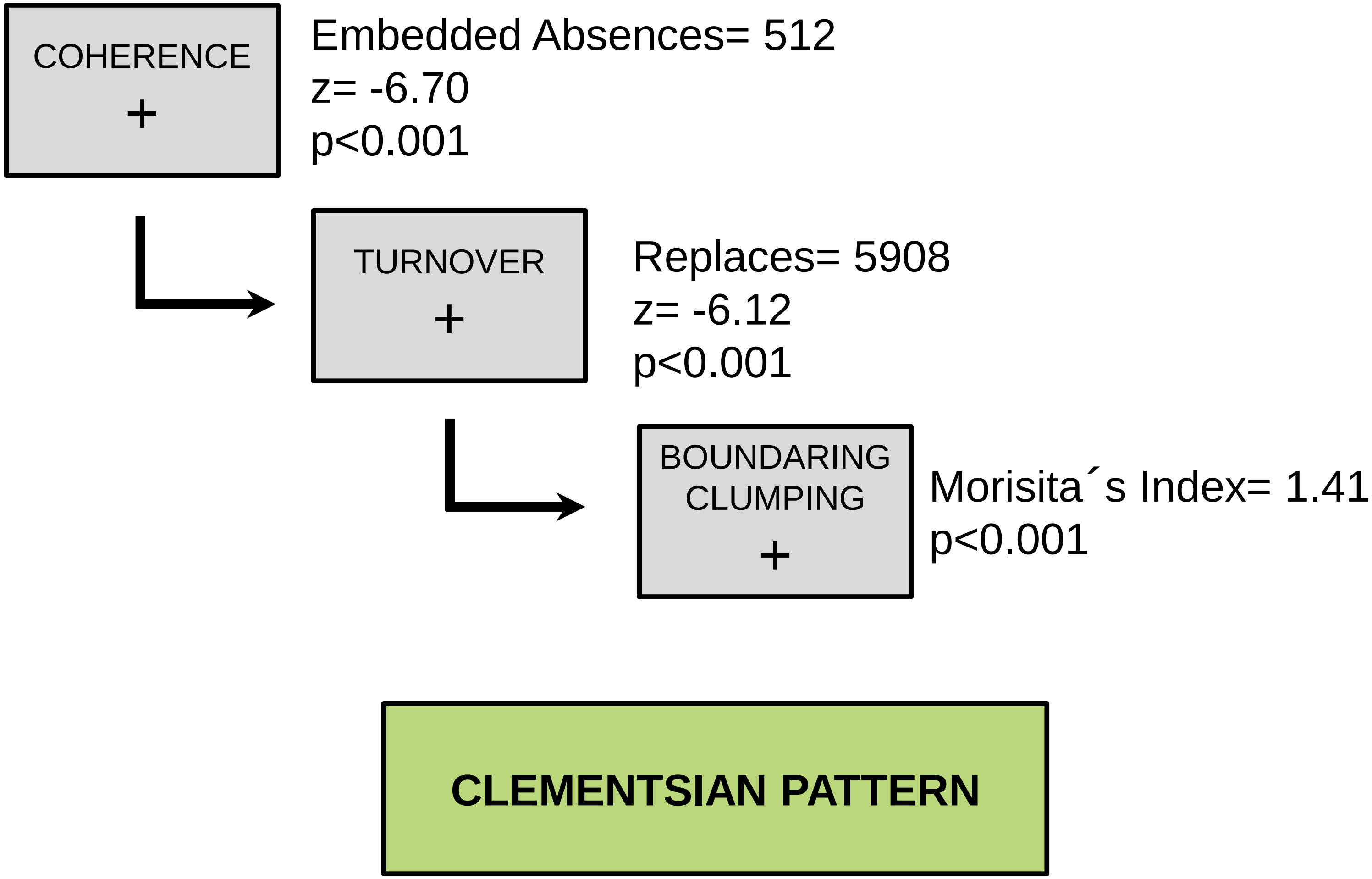
↓

Hirudinea – 0.12%

Taxa	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Helobdella		X										X											
Hirudinea		X																					
Pisidium																		X					
Sphaerium		X										X							X				
Menetus					X																		
Galba		X			X																		
Radix																		X					
Planorbarius		X																					
Gyraulus																			X				
Ancylus					X																		
Gerris	X										X						X					X	X
Naucoris		X					X								X			X					X
Mesovelia															X								
Microvelia	X																						
Anisops				X																			
Notonecta	X	X	X	X	X	X	X	X			X		X	X	X	X	X	X	X	X	X	X	X
Plea	X	X	X	X		X	X		X	X	X				X			X				X	X
Corixidae N			X		X	X	X	X	X				X	X	X					X	X	X	X
Cymatia				X			X																
Paracorixa	X		X						X												X		X
Sigara				X		X	X		X				X				X			X			
Baetidae sp.		X	X	X		X	X			X					X			X			X		X
Cloëon		X			X	X	X			X	X				X		X	X		X	X	X	X
Centroptilum				X		X				X									X				
Procloëon						X																	
Pseudocentroptilum															X								X
Acentrella						X																	
Caenis				X					X														
Aeshna															X						X		
Anax															X								
Libellula	X					X				X	X										X	X	X
Orthetrum				X							X							X				X	
Coenagrion	X		X	X															X		X		
Diplacodes															X								
Gomphus															X								
Lestes	X														X							X	X
Chalcolestes																			X				X
Sympecma																							X
Orthocladiinae	X	X	X	X	X	X	X		X	X	X	X			X	X	X	X	X		X	X	X
Chironominae	X	X	X	X	X	X	X		X			X			X	X	X	X	X		X		X
Tanypodinae		X	X	X	X	X	X		X		X	X	X		X	X	X	X	X		X	X	X
Ceratopogonidae										X	X	X						X	X				X
Culex			X												X								
Dixidae											X	X											
Chaoborus											X												X
Dytiscus																						X	
Colymbetinae																	X				X		
Agabus					X						X								X				
Hygrotus																				X			
Laccophilus	X	X	X	X											X								X
Hydrobius	X																	X					
Berosus			X	X																			
Enochrus											X												
Hydrophilus										X													
Hydrochara										X													
Nebrioporus				X																		X	
Graptodytes																				X			
Gyrinus																							X
Hydroporus					X			X				X		X									X
Hygrobiidae				X																		X	
Haliplus		X			X			X			X												
Dryopidae		X																					

RESULTS

Elements of Metacommunity Structure EMS



COHERENCE
+

Embedded Absences= 512
z= -6.70
p<0.001

TURNOVER
+

Replaces= 5908
z= -6.12
p<0.001

BOUNDARING CLUMPING
+

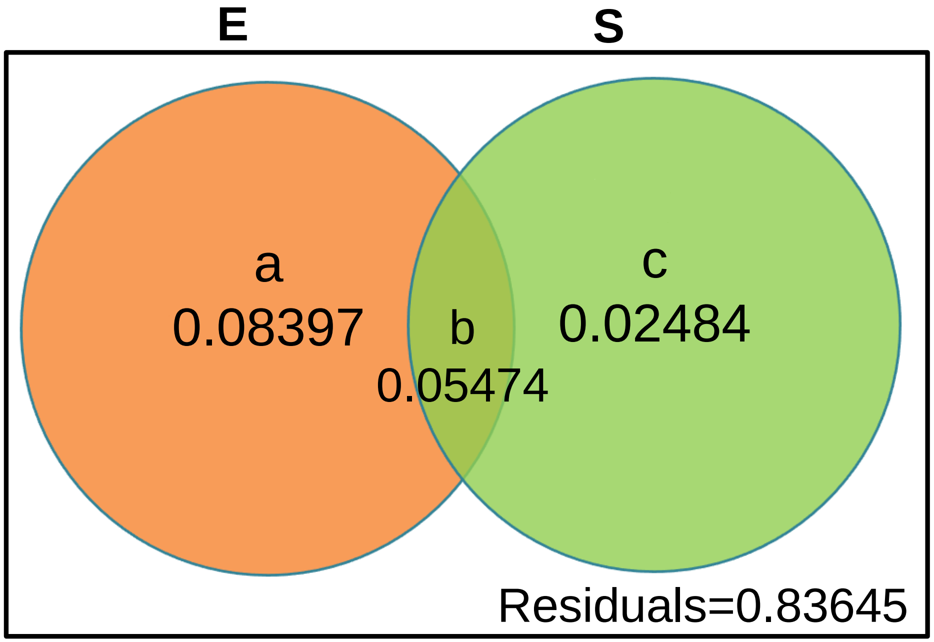
Morisita´s Index= 1.41
p<0.001

CLEMENTSIAN PATTERN

RESULTS

RDA analysis and variation partitioning analysis

Fraction	**df**	**Adj.R2**	**p**	**Variables in the model**
E (a ∪ b)	3	0.13871	0.001	Size, hydroperiod and altitude
S (b ∪ c)	2	0.07958	0.001	MEM1 and MEM4
E ∩ S (b)	5	0.05474	0.001	Size, hydroperiod, altitude, MEM1 and MEM4
1-(E+S)		0.83645		



DISCUSSION

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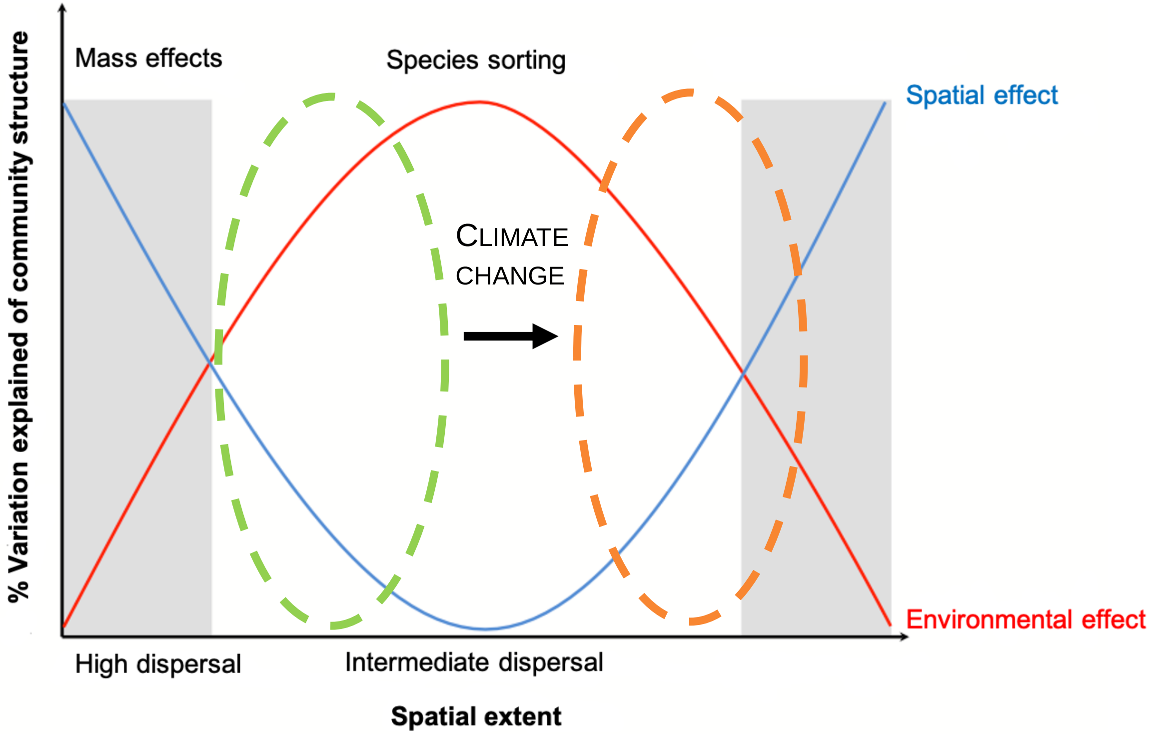
The environmental variation in macroinvertebrate community composition is due by environmental variables



Modified figure from Heino *et al.*, 2015

Environmental variables-Species sorting

MEM vectors-Mass effects

THANKS