Structure of benthic communities (macroinvertebrates and diatoms) in the lower stretch of a Mediterranean large river.

Luis Quevedo, Nuno Caiola and Carles Ibáñez.
IRTA, Aquatic Ecosystems Program, Sant Carles de la Ràpita, Catalonia, Spain.
luis.quevedo@irta.cat

Introduction

The Ebro River, located in the NE of the Iberian Peninsula (Fig. 1), is the largest Mediterranean river in Spain. With a basin surface of 85 550 km2, it is the Spanish river with the highest mean annual flow and one of the most important tributaries to the Mediterranean Sea. (Sierra et al., 2004; Ibánez et al., 2008; Prats et al., 2010; Ibáñez et al., 2012). The lower part showed a characteristic pattern of anthropogenic alterations (flow regulation and water pollution) present in large Mediterranean rivers.

The aim of this study was to examine benthic communities with regard to species composition, community structure and distribution patterns along spatial and temporal scales and to describe the main abiotic factors affecting communities of macroinvertebrates and diatoms.

The study area cover all the lower Ebro river morphological variability.

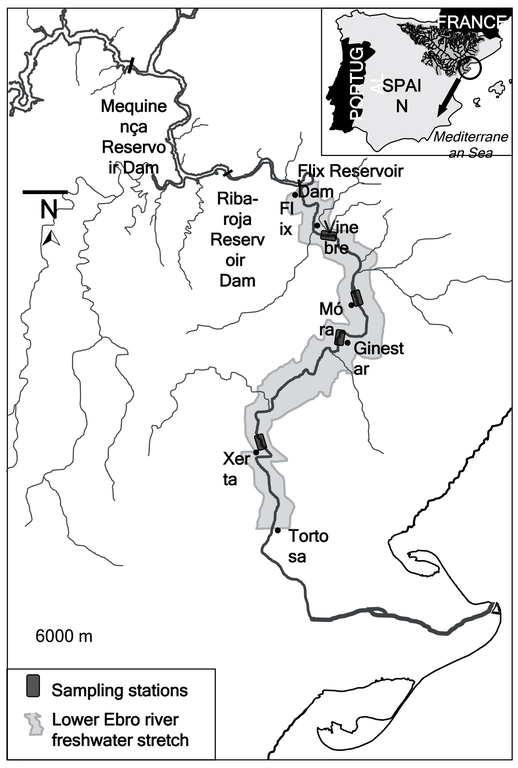

Fig. 1. Study area location and respective sampling sites.

Table 1. Macroinvertebrates community descriptive parameters (seasonal mean ± standard deviation) for each sampling station. Richness (S), Margalef index (d), Shannon-Wiener's diversity index (H', as log_2), Simpson dominance index (1-λ') and Pielou's evenness index (J'). Includes IBMWP (Iberian Biological Monitoring Working Party).

	S	d	H'(log_2)	1-λ'	J'	IBMWP
Spring						
E1	19±3	2.34±0.19	2.39±0.71	0.72±0.15	0.56±0.14	84±27
E2	17±0	2.41±0.00	1.54±0.00	0.46±0.00	0.38±0.00	55±0
E3	21±5	2.53±0.28	2.47±1.07	0.73±0.19	0.56±0.20	85±25
E4	14±0	1.94±0.00	1.87±0.00	0.62±0.00	0.49±0.00	40±0
E5	12±0	1.94±0.00	1.98±0.00	0.69±0.00	0.55±0.00	29±0
Summer						
E1	19±3	2.41±0.78	3.00±0.28	0.82±0.04	0.71±0.04	82±15
E2	20±0	2.97±0.00	3.37±0.00	0.86±0.00	0.78±0.00	82±0
E3	20±5	2.53±0.83	2.91±0.37	0.80±0.06	0.68±0.08	87±27
E4	27±0	3.47±0.00	3.70±0.00	0.90±0.00	0.78±0.00	112±0
E5	17±4	1.96±0.56	2.73±0.45	0.79±0.06	0.67±0.08	52±15
Autumn						
E1	13±0	2.70±0.00	2.09±0.00	0.60±0.00	0.56±0.00	37±0
E2	17±0	2.92±0.00	2.55±0.00	0.70±0.00	0.62±0.00	60±0
E3	16±0	2.56±0.00	2.16±0.00	0.67±0.00	0.54±0.00	56±0
E4	15±0	2.77±0.00	2.50±0.00	0.73±0.00	0.64±0.00	49±0
E5	17±0	2.31±0.00	2.29±0.00	0.67±0.00	0.56±0.00	51±0
Winter						
E1	14±0	2.69±0.00	2.75±0.00	0.81±0.00	0.72±0.00	43±0
E2	21±0	3.33±0.00	2.55±0.00	0.74±0.00	0.58±0.00	83±0
E3	18±0	3.65±0.00	3.22±0.00	0.85±0.00	0.77±0.00	70±0
E4	12±0	2.83±0.00	2.78±0.00	0.81±0.00	0.78±0.00	42±0
E5	15±0	3.19±0.00	2.85±0.00	0.81±0.00	0.73±0.00	51±0

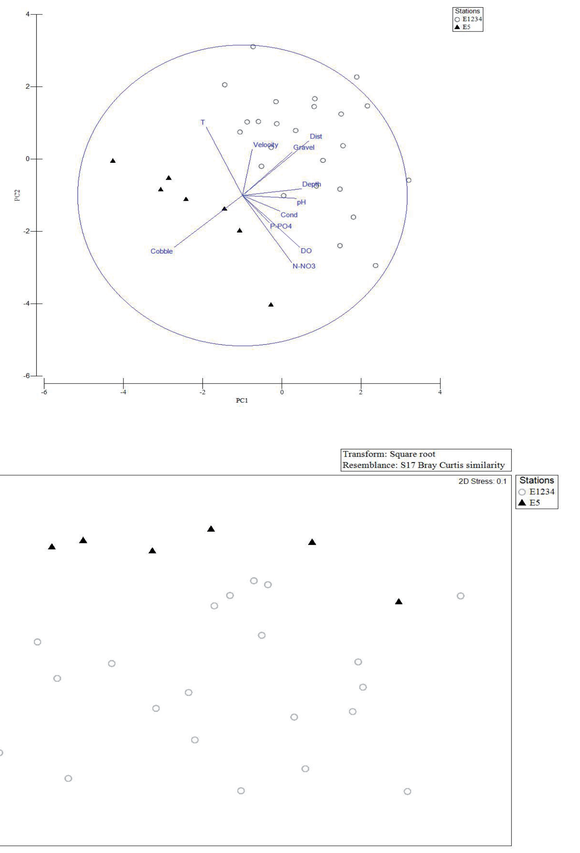

Fig. 2. Macroinvertebrates assemblages under spatial ordination in two axes PCA. Two dimensional MDS plots based on Bray-Curtis similarities of square-root transformed macroinvertebrate abundance data.

Material and methods

Four morphological river types were identified in the study area: steep stretches; moderately entrenched stretches; entrenched meanders; low gradient meanders. Five sampling sites (Fig.1) were selected to perform the surveys. The points were randomly selected in order to ensure the coverage of the morphological variability.

In order to determine species composition, community structure and distribution patterns along spatial and temporal scales, seasonal benthic organism (macroinvertebrates and diatoms) surveys were conducted in five sampling sections. Non-metrical Multidimensional Scaling (MDS), Similarity Percentage Analysis (SIMPER) and 1-way Analysis of Similarities Test were performed to identify differences in community composition and Principal Components Analysis (PCA) was carried out in order to illustrate patterns of association among the main limnological variables and assemblages of benthic communities.

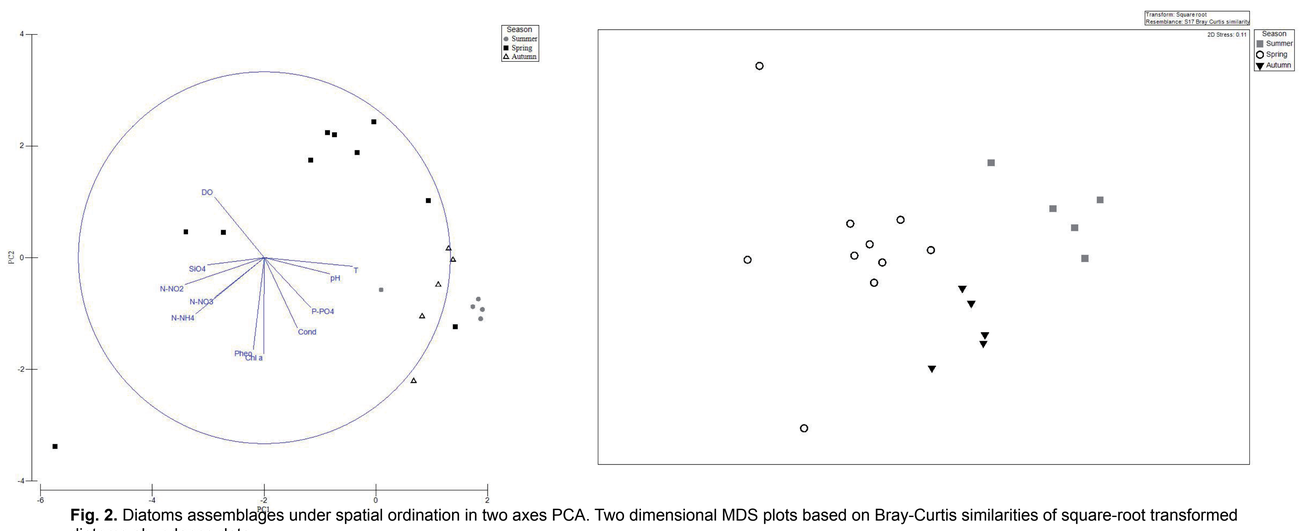

Fig. 2. Diatoms assemblages under spatial ordination in two axes PCA. Two dimensional MDS plots based on Bray-Curtis similarities of square-root transformed diatoms abundance data.

Table 2. Diatoms community descriptive parameters (seasonal mean ± standard deviation) for each sampling station. Richness (S), Margalef index (d), Shannon-Wiener's diversity index (H', as log_2), Simpson dominance index (1-λ') and Pielou's evenness index (J'). Includes IPS (Specific Polluosensitivity Index).

	S	d	H'(log_2)	1-λ'	J'	IPS
Spring						
E1	27±11	4.31±1.72	3.45±0.60	0.86±0.04	0.74±0.04	14.40±0.53
E2	29±0	4.67±0.00	3.32±0.00	0.84±0.00	0.68±0.00	13.90±0.00
E3	22±6	3.52±0.96	2.62±1.15	0.67±0.27	0.58±0.21	14.87±3.12
E4	23±0	3.60±0.00	3.33±0.00	0.85±0.00	0.74±0.00	13.70±0.00
E5	26±1	4.00±0.16	2.88±0.55	0.74±0.13	0.62±0.11	12.40±1.27
Summer						
E1	29±0	4.70±0.00	3.75±0.00	0.88±0.00	0.77±0.00	12.00±0.00
E2	25±0	3.93±0.00	3.21±0.00	0.83±0.00	0.69±0.00	10.90±0.00
E3	30±0	4.80±0.00	4.12±0.00	0.92±0.00	0.84±0.00	12.90±0.00
E4	28±0	4.46±0.00	3.52±0.00	0.86±0.00	0.73±0.00	11.50±0.00
E5	34±0	5.52±0.00	4.18±0.00	0.93±0.00	0.82±0.00	10.40±0.00
Autumn						
E1	36±0	5.71±0.00	3.69±0.00	0.87±0.00	0.71±0.00	11.90±0.00
E2	32±0	5.09±0.00	3.74±0.00	0.88±0.00	0.75±0.00	12.10±0.00
E3	32±0	5.15±0.00	2.72±0.00	0.72±0.00	0.54±0.00	13.70±0.00
E4	35±0	5.59±0.00	3.66±0.00	0.87±0.00	0.71±0.00	10.50±0.00
E5	31±0	4.95±0.00	3.49±0.00	0.85±0.00	0.71±0.00	8.70±0.00

Results and discussion

A total of 46 and 67 taxa of macroinvertebrates and diatoms species were identified respectively.

River conditions showed a lower degree of eutrophication than levels found in the early nineties, due mainly to reduction in phosphorus levels and the regulation system influenced the structure and composition of benthic communities.

Macroinvertebrate community was dominated by Oligochaeta in abundance and by Artropoda in species richness. During the sampling period a total of 66430 individuals were collected belonging to 46 different taxa that comprised 37 genus, 36 families, 20 orders, 8 classes and 6 phyla. Artropoda was the dominant phylum and accounted for 67.78% of the total abundance. Mollusca and Anellida contributed with 11.44% and 11.32% respectively. Chironomidae (28.19%), Gammaridae (15.72%) and Baetidae (9.06%) were the most abundant families. In terms of species richness, Artropoda contributed with 24 families followed by Mollusca with 7.

The highest richness mean values were found at E2 E3 E4 stations and diversity indices (Table 1) showed the same tendency; E3 station had the highest richness values with an annual mean value of 19 taxa; E5 station showed the lowest richness mean annual values and the lowest values for ecological status index. In terms of trophic structure, the dominant feeding guilds in the stretch were scrappers (48.52%) followed by shredders (24.28%) and deposit feeders (20.48%). Seasonal changes due the inter-annual variability were also registered showing a dominance of scrapers during spring and summer, of shredders in winter and deposit feeders in autumn

As changes in community composition were detected: the appearance and proliferation of black fly larvae (Simulium erythrocephalum), the decrease in abundance of the filter feeding mayfly larvae of Ephoron virgo and the presence of invasive species of bivalves (Dreissena polimorpha, Corbicula fluminea).

The mean values for IBMWP (Iberian Biological Monitoring Working Party) showed seasonal changes with different ranges in spring (29 - 85), summer (52- 112), autumn (37-60) and winter (42-83); the lowest value was registered at E5 (Table 1).

Macroinvertebrates MDS analysis (Fig. 2) showed two different communities, one corresponding to the station located next to the Flix dam (E5) and another that included stations located downstream (E1 E2 E3 E4). The PCA (Fig 2.) showed that the two firsts axes explained 27.2% and 23.9% of the total variation respectively. The first PCA axis summarized variables displaying spatial and hydromorphological variation, the distance to the dam was opposed to the coarser substrata composition which is related to the influence of the regulation system. These variables did not change along the study period. The second PCA component summarized the seasonal inter-annual variation, thus the temperature and water velocity were opposed to dissolved oxygen, conductivity and nutrients levels.

The diatom community was dominated by Nitzschia and the genus with the highest number of taxa was Navicula. The most abundant species were Amphora pediculus, Nitzschia dissipata var. dissipata and Cocconeis placentula var. lineata.

A total of 67 diatom species were found in the analysed samples; the most abundant genus were Nitzschia (33.76%), Amphora (21.98%), Navicula (11.37%) and Cocconeis (11.18%). Navicula was the genus with the highest number of taxa (15), followed by Nitzschia (9).

Amphora pediculus and Nitzschia dissipata were the most abundant species and occurred in all of the samples; Cocconeis placentula appeared as abundant species in most sites. Achnanthes minutissima (E3), Nitzschia palea (E4), Nitzschia inconspicua (E5) had punctual dominace.

The highest richness mean values were found at E1 and E4 stations and diversity indices (Table 2) showed the same tendency; E1 station had the highest richness values with an annual mean value of 29 taxa and E3 station showed the lowest richness mean annual values. IPS (Specific Polluosensitivity Index) mean values showed seasonal changes, in spring values from 12.40 to 14.40, in summer fluctuating between 10.40 and 12.90 and during autumn from 8.70 to 13.70; the lowest value was registered at E5 during autumn.

Diatoms MDS analysis showed no significant differences between stations at spatial scale but it presented differences at seasonal scale (Fig.3). The PCA (Fig.3) showed that the two firsts axes explained 36.9.1% and 22.3% of the total variation respectively. The first PCA axis summarized variables representing the seasonal inter-annual variation where the distance to the dam and the temperature were opposed to SiO4, N-NO2, N-NO3 and N-NH4 levels. The second axis showed that dissolved oxygen is opposed to conductivity and phosphate levels, summarizing the variation related to flow regimen altered by the regulation system.

Biological indices IPS (diatoms) and IBMWP (macroinvertebrates) showed values corresponding to "moderate" and "good" categories along all the stretch, with an exception for E5 where both founded a "poor" value. The indices displayed values mostly reflecting water quality; however, these indices showed little sensitivity to detect other anthropogenic impacts in the ecosystem as thermal pollution. Standardized methods based on biological indicators capable of integrating responses to different impact types are needed in order to develop specific indices for the ecological status assessment of Mediterranean large rivers.

Diatoms and macroinvertebrates reacted rather differently to environmental factors, diatoms were less sensitive than macroinvertebrates to physical changes in river habitat, and diatom community showed more sensibility to chemical factors. This pattern has been documented in previous comparatives studies between these two biota groups (Triest et al., 2001; Soininen and Könönen, 2004).Opposed to our initial expectations, in all studied river sections, no significant differences in community structure of diatoms and macroinvertebrates (except E5) were founded.

References:

Ibáñez, C., Alcaraz, C., Caiola, N., Rovira, A., Trobajo, R., Alonso, M. et al. (2012) Regime shift from phytoplankton to macrophyte dominance in a large river: Top-down versus bottom-up effects. Science of the Total Environment 416: 314-322.

Ibánez, C., Prat Fornells, N., Duran, C., Pardos, M., Munné Torrás, A., Andreu, R. et al. (2008) Changes in dissolved nutrients in the lower Ebro river: causes and consequences. Limnetica 27: 131-142.

Prats, J., Val, R., Armengol, J., and Dolz, J. (2010) Temporal variability in the thermal regime of the lower Ebro.

Sierra, J.P., Sánchez-Arcilla, A., Figueras, P.A., González Del Río, J., Rassmussen, E.K., and Mösso, C. (2004)

Soininen, J., and Könönen, K. (2004) Comparative study of monitoring South-Finnish rivers and streams using macroinvertebrate and benthic diatom community structure. Aquatic Ecology 38: 63-75.

Triest, L., Kaur, P., Heylen, S., and De Pauw, N. (2001) Comparative monitoring of diatoms, macroinvertebrates and macrophytes in the Woluwe River (Brussels, Belgium). Aquatic Ecology 35: 183-194.