

# Chapter 7

## DISTRIBUTION PATTERNS OF TRICHOPTERA ALONG IBERIAN MEDITERRANEAN COAST.

### INTRODUCTION

Community ecology, and also biogeography, is interested in detecting patterns in communities and determining the factors implied (Townsend, 1989). Several forces have been identified as the responsible of these distribution patterns. Ecologists traditionally have focused in external (i.e., abiotic environment) and intrinsic (i.e., biotic interactions) processes (e.g., Power *et al.*, 1988), whereas biogeographers include historical factors (e.g., see Myers & Giller, 1988; Cornell & Lawton, 1992; Lobo, 1998; Bonada *et al.*, Chapter 3). However, the differentiation between ecological and historical processes is not always easy (Endler, 1982), because of the different scale of observation in space and time used when these factors are analyzed (Ball, 1975; Legendre, 1990). As consequence of these factors, organisms are distributed in patches in space and time rather than randomly or homogeneously, generating spatial and temporal heterogeneity (e.g., Pringle *et al.*, 1988).

Stream ecosystems are organized in a hierarchical framework at different scales of observation (Frissell *et al.*, 1986; Church, 1996). Distribution areas and patterns are strongly scale-dependent (Menge & Olson, 1990; Allen & Hoekstra, 1991; Poff, 1992; Holt, 1993; Levin, 1992) with different factors operate constraining the presence and abundance of taxa at each scale level (Poff, 1997). Several studies have been performed to identify and understand distribution of macroinvertebrate patterns in large (e.g., Corkum, 1989; Quinn & Hickey, 1990; Marchant *et al.*, 1995; Wright *et al.*, 1994; Kay *et al.*, 1999, 2001) and small geographical area Carter s

(e.g., Ormerod & Edwards, 1987; Graça *et al.*, 1989) revealing the strong relationships between aquatic biota and environmental variables. Commonly, a large set of variables has been used to assess species autoecology and to understand distribution patterns. However, although factors determining distributions may be numerous and complex, are also intercorrelated (Prenda & Gallardo, 1992) and, in practice, few variables may allow us to define assemblages of species occurring in similar ecological conditions (e.g., Carter *et al.*, 1996; Wiberg-Larsen *et al.*, 2000). Multivariate analyses are very useful to demonstrate the hierarchical effect of variables in determining organism's distribution (Wiberg-Larsen *et al.*, 2000). The strong relationship between macroinvertebrates and environmental variables has been used all around to predict biological communities given a set of measured variables (e.g., Wright *et al.*, 1984; Smith *et al.*, 1989).

Mediterranean climate is characterized by a high seasonality with cold and wet winters and hot and dry summers (Köppen, 1923; Paskoff, 1973). The Mediterranean basin rivers subjected to these climatic patterns have an annual and interannual variability in discharge regimes, with floods and droughts frequent and predictable (Gasith & Resh, 1999; Bonada *et al.*, Chapter 3). Mediterranean fauna is well known to have a high diversity, level of endemism and complexity as the result of the interaction of complex historical and ecological factors, making the area unique from a biogeographical point of view (Balletto & Casale, 1989). In the Iberian Mediterranean area, numerous studies in taxonomy and ecology of macroinvertebrates have been done since the eighties (see Alba-Tercedor *et al.*, 1992), but although several taxonomical lists for specific macroinvertebrates cover all Iberian Peninsula, most of the ecological studies have been performed at a very small scale (e.g. one or few basins). Nowadays, studies at larger scales are increasing, and some of them are focused in looking at the environmental factors implied in the differential distribution of taxa (Mellado *et al.*, 2002; Vivas *et al.*, in press).

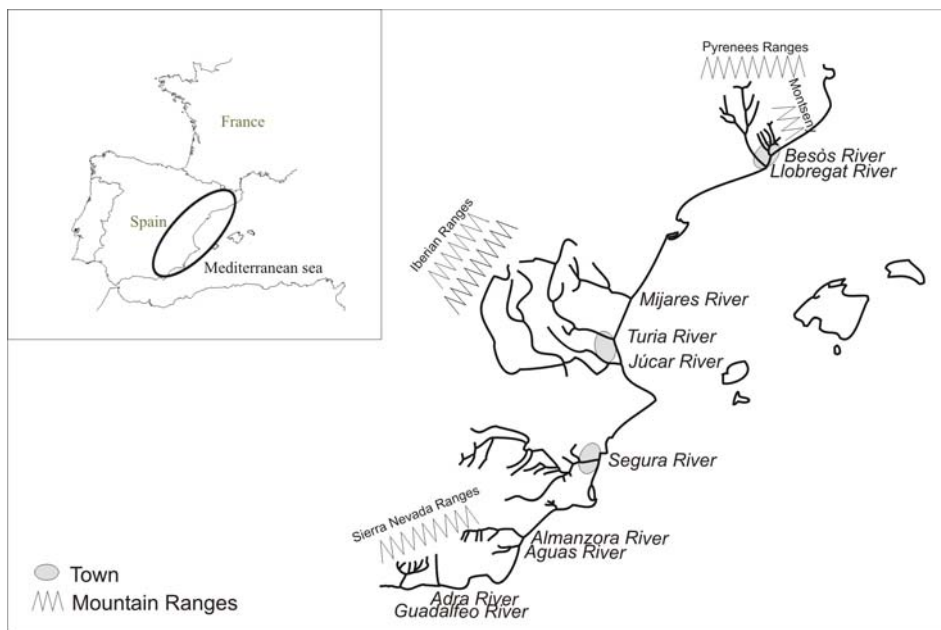
Trichoptera is a well-represented group in the Iberian Peninsula (with 331 species, Vieira-Lanero, 2000 with two new species from González & Ruiz, 2001 and Zamora-Muñoz *et al.*, 2002 —see Bonada *et al.*, Chapter 7) and highly endemic (González *et al.*, 1987). Although in this area Trichoptera has been studied since the middle of nineteenth century, most of these studies have been focused in taxonomical rather than ecological aspects (but see for example, García de Jalón, 1986). Moreover, an unequal knowledge between caddisfly fauna in north and south areas of Iberian Peninsula is still noticed, with more studies performed around where specialists are (González *et al.*, 1987). Recent faunistic studies in southern areas of Spain noticed also a high endemism (e.g., Ruiz *et al.*, 2001). Most of these studies are based on

imago stages rather than larvae, although several larval keys have been published in the last 20 years (e.g., Viedma & García de Jalón, 1980; Millet, 1983; Camargo & García de Jalón, 1988; Zamora-Muñoz & Alba-Tercedor, 1992; Zamora-Muñoz *et al.*, 1995; 1997), including the recent work of Vieira-Lanero (2000). Likely, because of the poor and the high endemicity and diversity of species in the Iberian Peninsula (González *et al.*, 1987) and the incomplete knowledge of their larvae (Vieira-Lanero, 2000), few studies have been done focused on the autoecology of immature stages (but see Puig *et al.*, 1981; Gallardo-Mayenco *et al.*, 1998), although some ecological information can be found either, in taxonomical (e.g., Vieira-Lanero, 2000; Ruiz *et al.*, 2001) and macroinvertebrate community studies using species level (e.g., Legier & Talin, 1973; Puig *et al.*, 1981; Herranz & García de Jalón, 1984; Giudicelli *et al.*, 1985; Graça *et al.*, 1989; Gallardo-Mayenco, 1993). However, in Spain few studies have been performed in large-scale areas looking at their distribution and factors implied, contrasting with several examples that can be found in Europe (Leuven *et al.*, 1987; Czchorowski, 1994; Wiberg-Larsen *et al.*, 2000), North America (Ross, 1963) and South Africa (de Moor, 1992). The aims of this study are (1) to present the distribution of caddisflies in the mediterranean coast of Iberian Peninsula and (2) to elucidate the main ecological factors responsible of it.

## **METHODOLOGY**

### **Sampling area**

In this study, ten basins along the Mediterranean coast in east Spain were sampled (Figure 1): Besòs, Llobregat, Mijares, Turia, Júcar, Segura, Almanzora, Aguas, Adra and Guadalfeo (an extensive description of studied basins can be found in Robles *et al.*, in prep). The area is subjected to a mediterranean climate (Köppen, 1923), with a significant spring and autumn rainfall. Overall, along the coast, a thermal and pluviometric gradient is present (Robles *et al.*, in press), with annual precipitation going from less than 300 mm in the more arid basins in the southeast to over 800 mm in northern basins or in some other areas. Limestone and sedimentary materials are dominant, although some siliceous areas are also present as Sierra Nevada, Pyrenees and Montseny ranges (Figure 1). Sclerophyllous and evergreen trees and shrubs are dominant in basins, although in some areas deciduous and coniferous forests are present. However, vegetation has been altered since the beginning of human settlement (Grove & Rackman, 2001), and nowadays only some headwaters remain in a natural condition.



**Figure 1.** Basins sampled in the GUADALMED Project.

Because of the seasonality of the climatic patterns and the variability in landscape, topography and geomorphology, rivers in the sampled basins are highly variable in space and time. Overall, sampled rivers are subjected to high annual discharge variability, more or less important depending on the local conditions, with frequent floods and droughts (Molina *et al.*, 1994; Gasith & Resh, 1999). In space, a high variability of rivers have been sampled (Bonada *et al.*, in press a): alpine, siliceous and short rivers from Sierra Nevada, longer and calcareous rivers from Pyrenees and Iberian Ranges; small rivers and tributaries with a temporary condition, karstic streams and saline ramblas in the south-east.

As in other mediterranean regions, sampled basins have been largely affected by human activities (Trabaud, 1981) as agriculture, cattle, urbanization, salinization, water abstraction and regulation... (Conacher & Sala, 2001). All these factors have contributed to the river alteration in a direct or indirect way (Prat, 1993).

### Sampling sites

A total of 157 sampling sites have been surveyed along Iberian Mediterranean coast four times in 1999 (spring, summer, autumn and winter) and three times in 2000 (spring, summer and autumn). They are part of the GUADALMED Project to assess the ecological status of the

Spanish mediterranean rivers according to the Water Framework Directive (European Parliament and Council, 2000). Sites are more or less equally distributed among all basins, and they include reference and non-reference sites (see Bonada *et al.*, in press b, for details in defining reference conditions). To study caddisfly distribution, only data from the first year was used. Several sampling sites and or seasons did not present Trichoptera larvae because the high pollution or because drought (mainly in summer). Thereby, data matrix was reduced to 372 samples (sites x seasons).

The variety of sampled river types and reaches implies the presence of different riparian communities with reaches without a structured riparian vegetation by natural conditions (i.e., ramblas and ephemeral rivers) to well preserved riparian forests in the headwaters of main rivers or tributaries (Suárez *et al.*, in press). However, the high human activity present in the sampled basins imply an extreme human alteration of riparian areas (Prat *et al.*, 1997, 1999) with numerous species introductions as *Platanus hispanica*, *Populus deltoides*, *Robinia pseudoacacia* and *Nicotiana sp.* Only in some reference and permanent headwaters, communities of *Salix alba*, *Corylus avellana*, *Populus nigra* and *Populus alba* are dominant. Sampling sites present a high variability in substrate types that enable the presence of abundant instream vegetation (e.g., mosses, diatoms, zygnetales and *Cladophora sp.*) and macrophytes (e.g., *Apium nodiflorum*, *Veronica sp.*, *Rorippa sp.* and *Chara sp.*)

### **Sampling procedure**

Sites were sampled following GUADALMED Protocol (Jáimez-Cuéllar, in press; Bonada *et al.*, Chapter 1) which is mainly designed as a bioassessment method, but the fine mesh size used (250 µm) and the absence of sampling restrictions in time, comparing with other procedures, allow us the use of samples for macroinvertebrate community studies (Bonada *et al.*, Chapter 6).

In each site, the index QBR for riparian quality (Munné *et al.*, 1998; in press; Suárez & Vidal-Abarca, 2000) and the IHF index for habitat diversity (Pardo *et al.*, in press) (see Annex 1 and 2 for the field sheets used in both indexes) were applied. Several physical and chemical parameters were measured *in situ* as pH, oxygen (mg/l and %), temperature, conductivity and discharge. Other water quality variables as ammonium, nitrites and phosphates were analyzed in the lab using the methods of GUADALMED Project (see Toro *et al.*, in press).

Macroinvertebrate samples were collected in riffles and pools with a kick-net of 250 µm mesh size. Samples were firstly examined in the field, and successive samples in both habitats are

taken until no more families were found by the observer. Several invertebrates seen in the field but not taken in the sample were also recorded, as the large Heteroptera and Coleoptera. Samples were preserved in alcohol 70% and sorted in the lab. Caddisfly taxa were identified at the maximum level possible, and rank of abundances was recorded for each taxa: 1 from 1-3 individuals, 2 from 4-10, 3 from 11-100 and 4 for more than 100 individuals. Because the large amount of undescribed larvae in the Iberian Peninsula (Vieira-Lanero, 2000) we were not able to identify all taxa at species level with certainty. When it was possible pupae and adults were collected in the field to ensure larvae identifications. Moreover, in some cases mature larvae were reared in the lab using a system inspired in Vieira-Lanero (1996).

## **Data analysis**

### *Selecting biological data matrix*

When macroinvertebrates are identified at the more precise taxonomical level possible, several difficulties are present when data matrices are used, because usually a mix of taxonomical level is found. Three situations may be responsible to that: (1) small individuals (first larvae stages) usually are difficult to identify at genus or species level, (2) as the knowledge of species of larvae is lower than the imagos, some species can be identified with more certainty than others, and (3) when it is impossible to achieve species level with larvae but some pupae have been collected and identified at species level. Consequently, different taxonomical levels are mixed between sites and even in a site, what may be a problem to achieve some objectives at community level (Cuffney *et al.*, 2002). To minimize this problem, the caddisfly data matrix with all individuals identified at maximum possible level (called 'caddis-max') was compared with the same matrix modified (called 'caddis-mod') according to the following assumptions:

(1) If in one sample some individuals were identified with certainty at species level but small individuals were keeping at family (or genus), only species or genus data was used for that sample. However when all individuals from the sample were unable to be identified they were kept in family (or genus) level to avoid losses of information. That was a frequent case in Hydropsychidae and Rhyacophilidae.

(2) If in one sample individuals were identified at genus but some pupae were collected and determined at species level, pupae were used at genus level jointly with the rest of individuals.

Both matrixes, caddis-max and caddis-mod, were compared using a Mantel test (Mantel, 1967) with the PCORD program (McCune & Mefford, 1999). This statistic method test differences between two similarity or distance matrices with the same objects (samples) to determine if distances among objects in one matrix (e.g., caddis-max) are or are not linearly correlated with the ones in the second matrix (e.g., caddis-mod). This test is equivalent to a non-parametric and multivariate test useful when biological data with many zeros is used. The result is a Mantel's standardized correlation coefficient ( $r_M$ ) tested by random permutations (999 runs).

#### *Spatial changes in caddisfly assemblages*

Two ordination techniques of multivariate data were applied to analyze distribution patterns of caddisflies. Firstly, an indirect analysis of Correspondence Analysis (CA) using biological data was performed. This ordination technique allows us to relate objects (samples) and descriptors (taxa) in a low-dimensional space. The measure used is the  $\chi^2$ , appropriated for semiquantitative data. It has been considered to produce better results than Principal Coordinate Analysis (PCA) with biological data, because matrices usually have numerous null values and  $\chi^2$  distance exclude double-zeros (Legendre & Legendre, 1998). Eigenvalues results (an indication of the percentage of variability explained by each canonical axis) were kept and compared with the ones obtained using a partial Canonical Correspondence Analysis (pCCA) to understand the proportion of caddisfly distribution explained by measured environmental variables. Partial CCA analysis is a direct ordination method similar to partial Redundancy Analysis (pRDA) but using  $\chi^2$  rather than Euclidean distances. This method obtains samples ordination according to the environmental constrains provided by an environmental variables matrix, and extracting the influence of some covariates on the biological data. A pCCA analysis was performed in front of a simple CCA to extract the influence of seasonality in sampling samples, because it presented a significant effect after a MRPP test (Multi-response Permutation Procedures) comparing four sampled seasons ( $A=0.003$ ,  $p\text{-value}=0.022$ ). Seasonality was included as four dummy covariables (spring, summer, autumn and winter). Rare species were down weighted to avoid bias in the final results in CA and pCCA analysis.

Environmental data matrix was built up using the variables measured in GUADALMED Project (Table 1). Physical and chemical parameters included are those measured in the field or obtained in the lab. Oxygen was removed from the analysis because the incomplete data set. Biological indicators of the composition and diversity of the macroinvertebrate community were also used, as IBMWP (Alba-Tercedor y Sánchez-Ortega, 1988; Alba-Tercedor, 1996; Alba-Tercedor & Pujante, 2000), and the IASPT (the ratio between IBMWP and number of taxa).

Geomorphological variables as the basin geology, altitude, stream order and so on were also measured for each site and included in the analysis (variables from group C in Table 1). Finally, complete data obtained from QBR and IHF in each site (variables from group D and E in Table 1 —see Annex 1 and 2 for field sheets) were included. A variable measuring temporality was added to the analysis (group A variable in Table 1) to check its influence on the caddisfly distribution. Variables were tested for autocorrelation using the non-parametric Spearman correlation coefficient. Variables highly correlated with the others were deleted from the analysis. Because most of the variables had a non-normal distribution (after a Shapiro-Wilk's test) and some of them were highly skewed (e.g., conductivity, nitrites, ammonium) they were log-transformed previously to the multivariate analysis. Canonical axes obtained with the pCCA ordination and environmental variables (selected by forward selection method) were tested for significance using a Monte Carlo permutation test (199 runs). The CANOCO Program was used to compute all ordination techniques (ter Braak & Smilauer, 1998).

To elucidate the meaning of canonical axis and understand the factors explaining caddisfly distributions, r-Pearson correlations were calculated between canonical axis and environmental variables. Several groups of samples with different caddisfly assemblages explained by different environmental variables were differentiated in the pCCA plots. To corroborate these groups from a statistical point of view, samples were clustered using its projections into canonical axis with a k-means method. This method divides samples in k-groups predefined using the number of the different caddisfly associations seen in the pCCA results. The analysis looks for groups of samples maximizing the differences among groups of samples and minimizing differences among samples from the same group (Legendre & Legendre, 1998). Finally, a discriminant analysis step-by-step using the Wilks' Lambda method with SPSS (SPSS, 1999) was used to select the environmental variables more significant in defining each group of caddisfly associations. The Wilks' Lambda statistic is calculated for each variable and has values between 0 and 1, with values near 0 indicating that groups present differences for that variable. Consequently, the method step-by-step identifies in hierarchical way variables with a minimum value of Wilks' Lambda. After that, the final selection of discriminant variables is done using the F statistic and a fixed p-value associated at 0.05 to enter a variable and 0.10 to remove it as default (Ferrán-Aranaz, 2001).



**Table 1.** Variables measured and used in the analysis. A=variable assessing temporality; B=physical, chemical and biological variables; C=geomorphological variables; D&E=structural variables. D corresponds to the values from each section from the index of habitat diversity (IHF) proposed by Pardo *et al.* (in prep). E corresponds to the values of each section from the index of riparian vegetation quality (QBR) proposed by Munné *et al.* (1998). The field sheet of both indexes is in Annex 1 and 2.

Variable	Code	Considerations
A Temporality	Tempo	Number of seasons that the rivers was dried: (0) permanent, (1) 1 season, (2) 2 seasons, (3) 3 seasons
NH <sub>4</sub> <sup>+</sup>	NH4+	Concentration in mg/l of NH4+
N-NO <sub>2</sub> <sup>-</sup>	NO2-	Concentration in mg/l of N-NO2-
P-PO <sub>4</sub> <sup>3-</sup>	PO43-	Concentration in mg/l of P-PO43-
Discharge	Discharge	Water discharge in l/s
B pH	pH	Water pH
Temperature	Tempe	Water temperature in °C
Conductivity	Conductivity	Water conductivity at 25°C in mS/cm
IBMWP	IBMWP	Biological index for water quality (Alba-Tercedor & Sánchez-Ortega, 1988)
IASPT	IASPT	Relationship between IBMWP and number of families
%sil-b	%Sil	Percentage of siliceous materials in basin from each site
%cal-b	%Cal	Percentage of calcareous materials in basin from each site
%sed-b	%Sed	Percentage of sedimentary materials in basin from each site
C Basin Area	Basin-Area	Basin area drained in each site
Altitude	Altitude	Altitude from each site in m.a.s.l.
Stream Order	Str-Ordre	Stream order at 1:250000
Channel Width	Chan-Width	Channel Width: until 1m (1), from 1 to 10m (2), over than 10m (3)
Channel Shape	Chan-Shape	Channel Shape according to the QBR field sheet
Embeddedness	Embed	The extent of embeddedness of the stream bed
Riffles vs. Pools	R/L	It is measure according to the riffles frequencies in sampling reach
Substrate composition	Substrat	Types and abundance of substrates present in sampling reach
D Flow and Depth regimes	Flow-Depth	Types of regimes in sampling reach
Shade	Shade	% of shade over the sampling reach
Heterogeneity elements	Hetero	Number and abundance of heterogeneity elements as leaf litter, branches, logs...
Instream Vegetation	Inst-Veg	Types and abundance of different instream vegetation formations
Riparian cover	Rip-Cove	Proportion of the riparian are cover by trees and shrubs
Riparian structure	Rip-Stru	Proportion of riparian vegetation composed by trees and shrubs separately
Riparian Quality	Rip-Qual	Absence of introduced species, and other human impacts in riparian vegetation
Channel Quality	Chan-Qua	Absence of human impacts altering channel form.

Once groups of samples and caddisflies and the significant environmental variables associated were established, significant differences between groups of samples in caddisfly assemblage were checked using a MRPP analysis with 999 runs. Further, an IndVal (Indicator Value) method (Dufrêne & Legendre, 1997) was applied to get the caddisfly assemblage more representatives in each group of samples. This procedure, examine characteristic taxa from a predefined group of objects (from the k-means) according to the presence and abundance of each taxa in each group independently of the others. Each taxon has associated an indicator value (IV-value) and a p-value obtained by Monte Carlo permutations (9999 runs). PCORD Program (McCune & Mefford, 1999) was used to carry out this analysis.

### *Seasonal changes in caddisfly assemblages*

To check the effect of seasonality and study changes in caddisfly community along year, a CCA analysis was performed for all samples using seasons as dummy variables. Rare species were down weighted. Canonical axes were tested for significance using a Monte Carlo test with 199 runs.

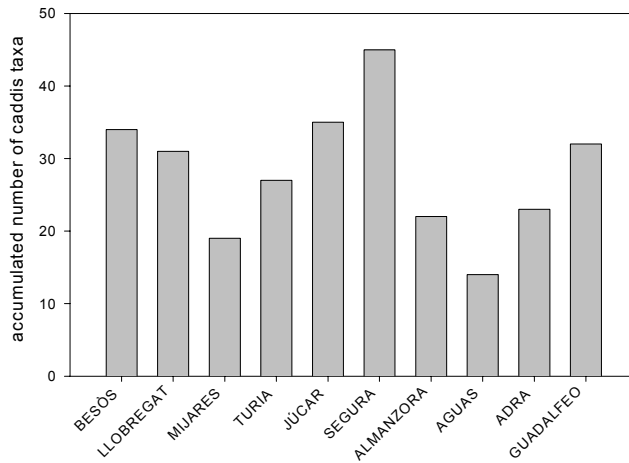
### *Variance partition of spatial and temporal patterns*

To determine the proportion of all caddisfly variability explained by measured variables and seasonality and their interaction, a Variance Partition was performed (Bocard *et al.*, 1992). To carry out this analysis, two CCA and two pCCA were performed: (1) with environmental variables, (2) with seasonality variables, (3) with environmental variables and seasonality covariables and (4) with seasonality variables and environmental covariables. (3) and (4) steps (pCCA) allow us to separate what is purely environment or seasonality and what is a result of the interaction. The sum of canonical eigenvalues of each analysis respect the sum of all eigenvalues (i.e., inertia) gives the percentage of variation explained by each group of variables. Non-explained variability was also calculated. Moreover, the percentage explained by environmental variables was partitioned to detect the proportion attributed to geomorphologic, temporality, physical-chemical and biological parameters. To perform that, successive CCA analysis using each subgroup of variables were done, and sum of all canonical eigenvalues were kept to calculate percentages.

## **RESULTS**

### **Taxa distribution**

A high and significant correlation was obtained comparing caddis-max with caddis-mod matrix ( $r_M=0.9822$  and  $p\text{-value}=0.0101$ ) indicating that similar information is provided using both matrixes. We decided to use the caddis-mod matrix to simplify the analysis and the interpretation of final results. A total of 71 taxa (including species and genus) were obtained (Annex 3). Taxonomical notes of these taxa are found in Bonada *et al.* (Chapter 6). Number of taxa is variable between basins (Figure 2). Segura basin presents the highest value of taxa whereas in Aguas and Mijares less than 20 taxa have been found. The rest of basins present intermediate values between 20 and 35 taxa. Some of collected taxa are ubiquitous whereas other are exclusive from one or more basins.



**Figure 2.** Number of accumulated taxa found in each sampling basin. Basins are ordered from north to south.

Table 2 represents the maximum of abundances of the most common caddisfly taxa (more than 1% of its presence in all samples) for each basin. Only *Hydropsyche* gr. *pellucidula* and *Hydroptila* sp. (Table 2) have been found in all sampled basins. Many caddisflies lack in only one basin, as *Agapetus* sp., *C. marginata*, *M. aspersus*, *H. exocellata*, *Polycentropus* sp., *Tinodes* sp.). In general, several taxa are absent in northern basins whereas other do in the southern ones. For instance, *Athripsodes* sp., *Rh. nevada*, *S. argentipunctellus*, *H. infernalis*, *M. moestum*, have been widely collected in most of southern basins (Segura, Almanzora, Aguas, Adra and Guadalfeo). Instead, *Limnephilus* sp. (mainly from *guadarramicus* species), *H. sp1*, *Rh. dorsalis*, *Chaetopteryx* sp., *H. radiatus*, *H. siltalai*, *M. azurea* and *P. cingulatus* are more distributed in northern basins (Besòs, Llobregat, Mijares, Turia and Júcar). Segura basin, often displays a mixture of taxa widely distributed in northern and southern basins, as *H. siltalai*, *H. sp1*, *Chaetopteryx* sp., *Rh. nevada*, *H. infernalis* and *M. moestum*. Some affinities can be observed between Besòs/Llobregat and Adra/Guadalfeo (the most northern and southern basins respectively) with *P. latipennis*, and the more widely distributed *P. montanus*. On the other hand, *O. albicorne* and *Rh. gr. tristis* have been collected only in Besòs and Llobregat basins, whereas *A. chauviniana* and *Rh. cf. occidentalis* were found in Adra and Guadalfeo basins. Some exclusive families have been collected in the large rivers Turia, Júcar and Segura, as *Ithytrichia* sp., *C. lepida*, *Ceraclea* sp., *O. angustella* and *H. brevis*.

**Table 2.** Maximum abundance recorded in each basin for each caddisfly species. Taxa are ranked according its exclusivity from northern to southern basins. Each sample is represented by one or two letters from the basin: B=Besòs, L=Llobregat, M=Mijares, T=Turia, J=Júcar, S=Segura, AL=Almanzora, AG=Aguas, AD=Adra, G=Guadalfeo.

	B	L	M	T	J	SE	AL	AG	AD	G
<i>Odontocerum albicorne</i>	2	1	0	0	0	0	0	0	0	0
<i>Rhyacophila gr. tristis</i>	1	1	0	0	0	0	0	0	0	0
<i>Halesus radiatus</i>	2	1	2	2	3	0	0	0	0	0
<i>Wormaldia</i> sp.	3	0	0	1	1	0	0	0	0	0
<i>Rhyacophila dorsalis</i>	1	3	2	2	1	0	0	0	0	0
<i>Potamophylax cingulatus</i>	2	3	0	0	2	0	0	0	0	0
<i>Mystacides azurea</i>	2	2	2	1	1	2	0	0	0	0
<i>Chaetopteryx</i> sp.	1	1	0	2	1	1	0	0	0	0
<i>Tynodes waeneri</i>	1	0	0	0	0	1	0	0	0	0
<i>Hydropsyche siltalai</i>	4	4	0	0	2	1	0	0	0	0
<i>Stenophylax</i> sp.	1	0	0	0	1	3	1	0	0	0
<i>Limnephilus</i> sp.	4	2	3	2	3	0	0	1	0	0
<i>Hydropsyche</i> sp1	0	1	1	0	3	3	0	0	0	0
<i>Hydropsyche bulbifera</i>	0	0	2	0	0	3	0	0	0	0
<i>Hydropsyche brevis</i>	0	0	1	2	3	3	0	0	0	0
<i>Ithytrichia</i> sp.	0	0	0	2	2	1	0	0	0	0
<i>Ceraclea</i> sp.	0	0	0	0	1	1	0	0	0	0
<i>Cheumatopsyche lepida</i>	0	0	0	0	3	2	0	0	0	0
<i>Drusus bolivari</i>	0	0	0	0	0	2	0	0	0	0
<i>Metalyse fragilis</i>	0	0	0	0	0	1	0	0	0	0
<i>Allogamus</i> sp.	0	1	0	1	0	3	3	0	0	0
<i>Halesus tessellatus</i>	2	0	0	1	0	1	0	0	3	2
<i>Rhyacophila meridionalis</i>	2	3	0	0	0	2	2	0	2	0
<i>Agapetus</i> sp.	3	0	1	1	3	3	1	3	3	3
<i>Potamophylax latipennis</i>	1	3	0	0	0	0	0	0	3	2
<i>Polycentropus</i> sp.	3	3	0	2	2	3	3	2	2	2
<i>Sericostoma</i> sp.	2	3	0	1	2	3	0	0	1	2
<i>Plectrocnemia</i> sp.	1	2	0	0	1	2	0	0	1	1
<i>Philopotamus montanus</i>	3	1	0	0	0	1	0	0	1	2
<i>Hydropsyche instabilis</i>	3	2	3	3	0	3	3	0	3	3
<i>Hydropsyche exocellata</i>	4	4	3	3	4	2	3	0	3	1
<i>Mesophylax aspersus</i>	3	3	2	3	1	3	2	0	1	2
<i>Tynodes</i> sp.	1	1	1	1	1	1	2	1	0	2
<i>Hydropsyche gr. peucisium</i>	3	3	3	3	3	3	2	3	3	3
<i>Hydroptila</i> sp.	3	4	2	3	4	3	3	3	2	2
<i>Chimarra marginata</i>	0	4	3	1	4	1	1	3	2	2
<i>Rhyacophila munda</i>	0	0	2	1	1	3	2	2	2	3
<i>Setodes argentipunctellus</i>	0	0	0	1	2	3	3	3	2	1
<i>Lasiocephala basalis</i>	0	0	0	1	3	2	0	0	1	3
<i>Orthotrichia angustella</i>	0	0	0	0	3	0	0	0	0	0
<i>Oxyethira</i> sp.	0	0	0	0	0	2	2	3	0	0
<i>Micrasema moestum</i>	0	0	0	0	0	3	4	0	0	1
<i>Hydropsyche infernalis</i>	0	0	0	0	0	3	1	1	2	2
<i>Rhyacophila nevada</i>	0	0	0	0	0	3	3	0	1	2
<i>Athripsodes</i> sp.	0	0	0	0	0	0	3	1	1	2
<i>Anomalopterygella chawiniana</i>	0	0	0	0	0	0	0	0	1	2
<i>Rhyacophila cf. occidentalis</i>	0	0	0	0	0	0	0	0	1	2
<i>Micrasema longulum</i>	0	0	0	0	0	0	0	0	0	2

### Spatial patterns of distribution

Environmental variables were weakly correlated when rho-Spearman coefficient between pair of variables were obtained (not shown), and thereby none of them were excluded from the analysis.

Results from the pCCA analysis are in Table 3. Canonical axes from CA and pCCA analysis represent a low percentage of caddisfly variability in samples, with 7.4% in the first CA-axis and 5.8% in the first pCCA-axis. However, the results indicate that a high percentage of all caddisfly variability showed in the first CA-axis is explained by environmental variables (78.3% for the first axis, 42.3% for the second, 33.8% for the third and 31.6% for the fourth). This indicates that the measured variables are among the responsible to explain major differences in caddisfly distribution. Moreover, Monte Carlo permutation tests indicate that all canonical axes are significant with the set of variables used. Some variables (i.e., nitrites, discharge, temperature, channel shape, riparian quality, phosphates and riparian cover) were not significant (after applying the forward selection method in CANOCO Program) and consequently they were not used in the analysis. The pCCA graphs for samples and caddisflies and environmental variables are shown in Figure 3 (first and second axes) and 4 (second and third axes). Only the three first canonical axes were used because they include the maximum variability expressed by the environmental variables. First axis appears negatively correlated with altitude, siliceous basin, biological indexes and high values of all riparian and habitat features (Table 4), differentiating samples with good ecological quality located in

**Table 3.** Eigenvalues and % of explained variation obtained from CA and CCA analysis. Results from Monte Carlo test checking for axis significance in CCA are presented on the bottom.

<b>Correspondence Analysis (CA)</b>				
	X <sub>1</sub>	X <sub>2</sub>	X <sub>3</sub>	X <sub>4</sub>
Eigenvalues	0.733	0.646	0.549	0.484
Cumulative % variance	7.4	13.9	19.4	24.3

<b>Canonical Correspondence Analysis (PCCA)</b>				
	X <sub>1</sub>	X <sub>2</sub>	X <sub>3</sub>	X <sub>4</sub>
Eigenvalues	0.574	0.276	0.186	0.153
Cumulative % variance	5.8	8.7	10.6	12.1

<b>Monte Carlo test (199 permutations)</b>		
	F	p-value
Significance of first canonical axis	21.469	0.005
Significance of all canonical axis	3.715	0.005

headwaters at high altitude from lowland reaches. Second axis is positively related to chemical variables, discharge, basin area, channel width and others, whereas it is negatively associated with high values of riparian and biological quality, several habitat characteristics and temporality (Table 4). Finally, the third axis is associated to temperature, stream order and sedimentary geology in a positive direction and to riparian and habitat characteristics in the negative one (Table 4). According to Figure 3, a gradient of caddisfly species appear from left to right side of the graph and three groups may be differentiated. Headwaters and high altitude samples with a high substrate diversity, located in the left, are associated with *Glossosoma* sp., *A. chauviniana*, *M. longulum*, *H. tessellatus*, *Rh. cf. occidentalis* and *H. tibialis* whereas lowland rivers in the right present *H. exocellata*, *P. pusilla*, *P. cf. ctenophora* and *H. brevis*. In the middle, a group of midstream samples associated with several Hydropsychids, Philopotamids, Polycentropodids and Psychomiids are present. Second axis in Figure 3 appears to differentiate between small temporary streams from middle and large streams. Few taxa is associated to positive values of second axes, as *Rh. fasciata*, *Rh. dorsalis*, *Ecnomus* sp. and several Hydropsychids, characteristic from middle reaches.

**Figure 3.** pCCA plots representing first ( $X_1$ ) and second ( $X_2$ ) axis. The graph on the top shows the distribution of samples, and the one on the bottom the distribution of taxa. Adjacent graph display the position of environmental variables. Each sample is represented by one or two letters from the basin: B=Besòs, L=Llobregat, M=Mijares, T=Turia, J=Júcar, S=Segura, AL=Almanzora, AG=Aguas, AD=Adra, G=Guadalfeo.

**Table 4.** Pearson correlations (r) between environmental variables and the three canonical axis from CCA.

\*\*p-value&lt;0.01, \*p-value&lt;0.05. For codes explanation see Table 1.

	<u>X<sub>1</sub>-CCA</u>	<u>X<sub>2</sub>-CCA</u>	<u>X<sub>3</sub>-CCA</u>
Temporality	-0.017	-0.268 **	-0.017
NH <sub>4</sub> <sup>+</sup>	0.322 **	0.386 **	-0.080
NO <sub>2</sub> <sup>-</sup>	0.112 *	0.111 *	0.006
PO <sub>4</sub> <sup>3-</sup>	0.223 **	0.229 **	0.02
Discharge	0.191 **	0.337 **	0.040
pH	-0.042	0.106 *	0.025
Temperature	0.230 **	-0.072	0.275 **
Conductivity	0.641 **	-0.035	0.062
IBWMP	-0.490 **	-0.478 **	-0.013
IASPT	-0.596 **	-0.193 **	-0.108
%Sil	-0.382 **	-0.057	0.074
%Cal	0.454 **	0.185 **	-0.038
%Sed	0.395 **	-0.018	0.326 **
Basin-Area	0.597 **	0.370 **	0.022
Altitude	-0.561 **	-0.114 *	0.055
Stream Order	0.366 **	0.227 **	0.302 **
Channel Width	0.176 **	0.438 **	0.019
Channel Shape	-0.371 **	-0.088	0.048
Embed	-0.109 *	0.057	-0.237 **
R/L	-0.165 **	0.240 **	-0.235 **
Substrat	-0.112 *	0.211 **	0.146 **
Flow-Depth	-0.227 **	0.113 *	-0.192 **
Shade	-0.390 **	-0.182 **	-0.151 **
Hetero	-0.416 **	-0.157 **	-0.098
Inst-Veg	-0.089	0.125 *	-0.208 **
Rip-Cove	-0.404 **	-0.287 **	-0.01
Rip-Stru	-0.322 **	-0.299 **	-0.073
Rip-Qual	-0.271 *	-0.148 **	-0.135 **
Chan-Qual	-0.403 **	-0.203 **	-0.001



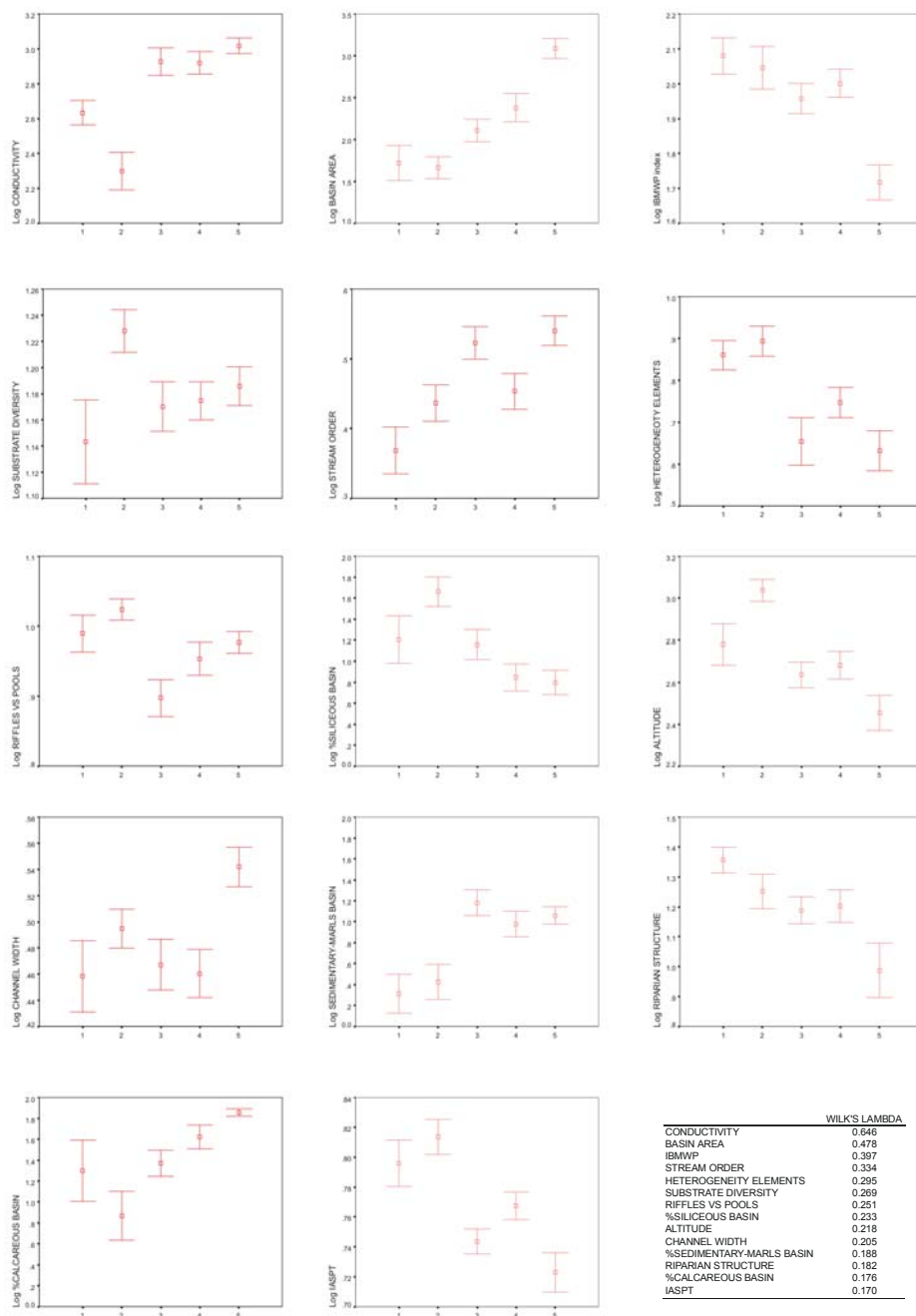




**Figure 5.** pCCA plots representing sites on first ( $X_1$ ) and second ( $X_2$ ) axis on the top, and first ( $X_1$ ) and third ( $X_3$ ) on the bottom. Samples are labeled according to the results from the K-means analysis. Circles represent the extension of each group.

On the other hand, more taxa is associated to the small rivers located on the negative part of second axis, as *M. minimum*, *Oxyethira* sp., *Wormaldia* sp., *Stenophylax* sp., *G. pellucidus*, *Agapetus* sp., *S. argentipunctellus*,... and the ones highly related to a well- developed riparian forest, *Beraea* sp., *Allogamus* sp., *Synagapetus* sp., *D. bolivari* or *H. digitatus*. In Figure 4 where second and third axes are plotted, samples from second axis are segregated more clearly than in Figure 3. Some temporary and sedimentary-marl samples with high natural conductivity and high stream order from the most arid basins of Aguas, Almanzora and Segura (Figure 4) are distinguished in the top-left part of the axis, with *H. infernalis*, *H. bulbifera*, *Agapetus* sp., *M. aspersus*, *Oxyethira* sp., *Rh. cf. munda* and *S. argentipunctellus*. Through the lower part of the axis, samples associated to middle reaches of rivers (in the central part of the graph) are associated with species as *Ithytrichia* sp., *Cyrnus* sp., *Polycentropus* sp., *C. marginata*, whereas more pristine headwaters (in the lower part of the graph) are characterized by *Wormaldia* sp., *G. pellucidus*, *M. azurea*, *Tinodes waeneri*, *Halesus* sp., *Lype* sp., *Rh. gr. tristis* and others. Consequently, from Figures 3 and 4, five groups of sites may be distinguished: headwater sites with high altitude, diverse habitat characteristics and siliceous basins (top-left from Figure 3); headwater samples at medium altitudes with high riparian structure and biological quality (bottom area of Figure 4); low altitude and temporary sedimentary samples with high conductivity (top-right in Figure 4); low altitude samples located in lowland reaches from medium to large rivers with a poor biological and chemical quality (top-right from Figure 3); and middle parts of river sites located at medium altitudes (central area of second axis from Figure 4). To verify the presence and identity of each group and to classify properly all samples, a k-means cluster using 5 pre-defined groups was applied to all samples. Figure 5 display de results of this analysis. Final k-means groups are those that we should expect according to the interpretations of samples in Figure 3 and 4. Group 4 is the biggest group with 102 objects, followed by group 3 with 97. On the other hand, smallest groups (k-means-1 with 39 samples and k-means-2 with 54) have samples highly dispersed indicating that more diverse and less abundant caddisfly are present.

Discriminant analysis selected 14 variables that differentiate k-means groups (Figure 6). Seven variables are geomorphological features (basin area, stream order, altitude, channel width, %siliceous, calcareous and sedimentary-marl basin) whereas the rest are habitat, riparian, habitat and biological properties. Conductivity is the only physical-chemical variable that discriminates groups of samples, being higher in groups 3, 4 and 5. According to Figure 6, group 1 and 2 correspond to headwaters samples differing in altitude, basin geology, channel width, stream order and substrate diversity. Two groups of samples appear located in middle



**Figure 6.** Results from the Discriminant Analysis, with the most significant variables between k-groups. Mean and confidence intervals at 95% are presented. Plots are ordered from top-left to bottom-right according to their weight in discriminant analysis.

reaches of rivers (k-means 3 and 4), characterized by intermediate altitude and channel width and lower riparian structure. Conductivity is also similar between both midstream groups although the higher percentage of sedimentary basins mainly composed by marls in group 3 and the dominance of pools with a lower IASPT, suggest us to consider it as a group of samples with rambla type features. In contrast, group 4 would correspond to common



**GROUP 1: CALCAREOUS/SILICEOUS HEADWATERS**

Calcareous and siliceous basin with a small area. Medium altitude. Low stream order and narrow channel. High biological quality and riparian structure. Riffles dominant with low substrate diversity and high heterogeneity elements. Water with low conductivity.



**GROUP 2: SILICEOUS HEADWATERS**

Mainly siliceous basins with small area. High altitude. Medium stream order and narrow channel. High biological quality and riparian structure. Riffles dominant with high substrate diversity and heterogeneity elements. Water with very low conductivity.



**GROUP 3: SEDIMENTARY-MARLS MIDSTREAMS**

Mainly sedimentary-marls basin with medium basin area. Medium-low altitude. High stream order and narrow channel. High biological quality and medium riparian structure. Low IASPT. Pools dominant with medium substrate diversity and scarce heterogeneity elements. Water with high natural conductivity.



**GROUP 4: CALCAREOUS/SEDIMENTARY MIDSTREAMS**

Calcareous and sedimentary basin with large basin area. Medium-low altitude. Medium stream order and narrow channel. High biological quality and medium riparian structure. Medium IASPT. Riffles and pools dominant with medium substrate diversity and heterogeneity elements. Water with high conductivity.



**GROUP 5: CALCAREOUS/SEDIMENTARY LOWLAND REACHES**

Calcareous and sedimentary basins with very large basin area. Low altitude. High stream order and wide channel. Low biological quality and riparian structure. Riffles and pools dominant with medium substrate diversity and scarce heterogeneity elements. Water with high conductivity.

**Figure 7.** Groups significance according to the results obtained from discriminant analysis.

midstreams with a mix of calcareous and sedimentary geology and riffles as a dominant macrohabitat. Finally, k-means-5 includes lowland reaches with calcareous and sedimentary basins and poor ecological quality. Thereby, according to our analysis, caddisfly assemblages along Mediterranean coast are segregated in five groups of samples differing in environmental conditions (see Figure 7). These groups can be defined as: (1) Calcareous/Siliceous headwaters, (2) Siliceous headwaters, (3) Sedimentary-marl midstreams, (4) Calcareous/sedimentary midstreams and (5) Calcareous/Sedimentary lowland reaches. In Table 5 the number of samples from each group separated by basins is presented.

**Table 5.** Number of samples in k-means groups detailed by sampling basins. Basins are ordered from north to south.

	<b>GROUP 1</b>	<b>GROUP 2</b>	<b>GROUP 3</b>	<b>GROUP 4</b>	<b>GROUP 5</b>
BESÒS	16	1	7	8	8
LLOBREGAT	10	0	2	11	31
MIJARES	2	2	5	12	6
TURIA	5	3	8	16	5
JÚCAR	5	1	3	22	28
SEGURA	2	3	17	16	0
ALMANZORA	0	5	12	8	0
AGUAS	1	0	11	3	0
ADRA	0	4	11	2	2
GUADALFEO	0	35	21	2	0
<b>TOTAL</b>	<b>41</b>	<b>54</b>	<b>97</b>	<b>100</b>	<b>80</b>

Interesting to notice that northern basins have most of the calcareous/siliceous headwaters (group 1) whereas siliceous headwaters are dominant in southern basins. Similarly, most of the medium and large rivers with lowlands that allow the presence of caddisfly are present only from Júcar through the north. Midstream reaches also appear quite segregated between northern and southern areas. Sedimentary-marl midstreams are dominant in Segura, Almanzora, Aguas, Adra and Guadalfeo, whereas northern basins have midstreams with influences by a more calcareous basin.

Differences between k-means groups in caddisfly community are highly significant according to MRPP results ( $A=0.2176$ ,  $p\text{-value}=0.000$ ). These differences are observed when IndVal results are analyzed (Table 6). Because of the low abundance and frequency of many caddisflies, few taxa have high indicator values ( $IV\text{-value}>25$ ) although many are

**Table 6.** IndVal results for each group of sites separately. Indicator values (IV-value) and significance for significant taxa in each group are presented. Taxa is ordered according to their p-value.

<b>CALCAREOUS/SILICEOUS HEADWATERS</b>			<b>SILICEOUS HEADWATERS</b>		
GROUP 1	IV-value	p-value	GROUP 2	IV-value	p-value
<i>Sericostoma</i> sp.	44.1	0.001	<i>Hydropsyche instabilis</i>	88.2	0.001
<i>Hydropsyche siltalai</i>	35.4	0.001	<i>Lasiocephala basalis</i>	58.8	0.001
<i>Limnephilus (guadarramicus)</i> sp.	22.1	0.001	<i>Rhyacophila nevada</i>	47.9	0.001
<i>Halesus radiatus</i>	22	0.001	<i>Athripsodes</i> sp.	39.6	0.001
<i>Rhyacophila dorsalis</i>	20	0.001	<i>Micrasema moestum</i>	21.7	0.001
<i>Potamophylax latipennis</i>	18.6	0.001	<i>Halesus tessellatus</i>	21.4	0.001
<i>Potamophylax cingulatus</i>	17.9	0.001	<i>Rhyacophila cf. occidentalis</i>	14.8	0.001
<i>Hydropsyche dinarica</i>	12.2	0.001	<i>Anomalopterygella chauviniana</i>	11.1	0.001
<i>Chaetopteryx</i> sp.	12	0.001	<i>Migrasema longulum</i>	11.1	0.001
<i>Wormaldia</i> sp.	10.3	0.001	<i>Philopotamus montanus</i>	9.3	0.001
<i>Polycentropus</i> sp.	24.7	0.002	<i>Potamophylax latipennis</i>	10.5	0.005
<i>Philopotamus montanus</i>	11.6	0.002	<i>Sericostoma</i> sp.	14.6	0.008
<i>Synagapetus</i> sp.	7.7	0.002	<i>Glossosoma</i> sp.	3.7	0.014
<i>Rhyacophila relicta</i>	5.1	0.01	<i>Brachycentrus (O.) maculatum</i>	3.7	0.028
<i>Mystacides azurea</i>	8.5	0.017	<i>Rhyacophila meridionalis</i>	5.3	0.041
<i>Halesus digitatus</i>	4.9	0.019			
<i>Plectrocnemia</i> sp.	10	0.02			
<i>Rhyacophila meridionalis</i>	6.5	0.021			
<i>Glyphotaelius pellucidus</i>	4.6	0.025			
<i>Rhyacophila gr. tristis</i>	6.7	0.033			

<b>SEDIMENTARY-MARLS MIDSTREAMS</b>			<b>CALCAREOUS/SEDIMENTARY MIDSTREAMS</b>		
GROUP 3	IV-value	p-value	GROUP 4	IV-value	p-value
<i>Hydropsyche gr pellucidula</i>	48.4	0.001	<i>Hydroptila</i> sp.	41.9	0.001
<i>Agapetus</i> sp.	24	0.001	<i>Hydropsyche gr. pellucidula</i>	27.1	0.001
<i>Mesophylax aspersus</i>	23.5	0.001	<i>Chimarra marginata</i>	24	0.001
<i>Rhyacophila munda</i>	21	0.001	<i>Hydropsyche brevis</i>	15.2	0.001
<i>Hydropsyche</i> sp.	12.8	0.001	<i>Limnephilus (guadarramicus)</i> sp.	10.5	0.001
<i>Hydropsyche infernalis</i>	11.5	0.001	<i>Cheumatopsyche lepida</i>	6.3	0.002
<i>Setodes argentipunctellus</i>	11.4	0.001	<i>Orthotrichia angustella</i>	4.9	0.003
<i>Stenophylax</i> sp.	4	0.0611	<i>Rhyacophila</i> sp.	11.9	0.004
<i>Rhyacophila cf. munda</i>	2.1	0.0611	<i>Hydropsyche sp1</i>	6.7	0.004
			<i>Polycentropus</i> sp.	14.4	0.017
			<i>Rhyacophila dorsalis</i>	7	0.033
			<i>Allogamus</i> sp.	5.1	0.034
			<i>Ithytrichia</i> sp.	4	0.035
			<i>Hydropsyche bulbifera</i>	2.6	0.048

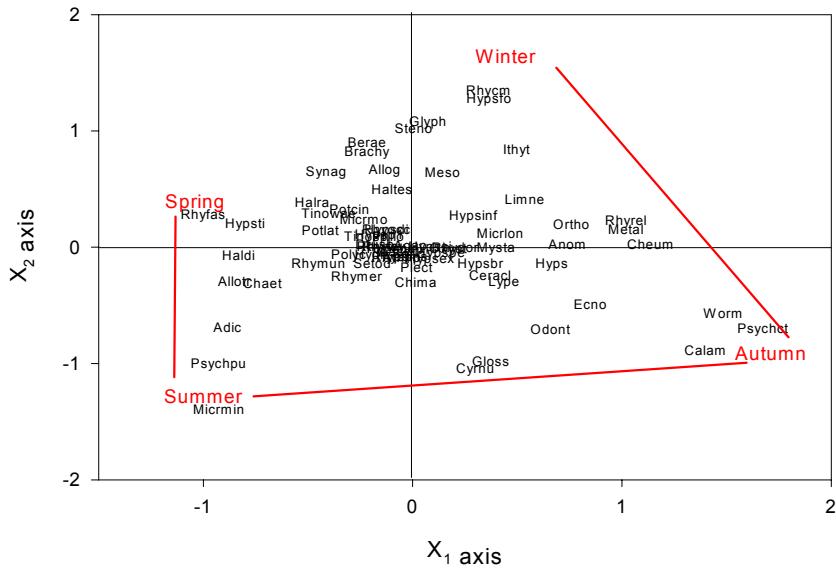
<b>CALCAREOUS/SEDIMENTARY LOWLAND RIVERS</b>		
GROUP 5	IV-value	p-value
<i>Hydropsyche exocellata</i>	95.6	0.001
<i>Ceraclea</i> sp.	2.2	0.1081
<i>Allotrichia pallicornis</i>	0.9	0.3934
<i>Rhyacophila</i> sp.	6	0.5295

high significant of each group ( $p < 0.01$ ). *H. exocellata* is highly indicator and significant from calcareous/sedimentary lowland rivers, whereas other taxa also present in this group are not significant (*Ceraclea* sp., *A. pallicornis* and some *Rhyacophila* undetermined). Many caddisfly are characteristic from calcareous/siliceous headwaters located in medium altitude from northern basins, as *Sericostoma* sp., *H. siltalai*, *H. dinarica*, *Rh. dorsalis*, *H. radiatus*, *H. digitatus*, *Chaetopteryx* sp., *Limnephilus* sp. (mainly from *guadarramicus* species), *P. cingulatus* and *latipennis*. Some of these taxa are shared by siliceous headwaters in the highest areas of Sierra Nevada, as *Sericostoma* sp., *P. latipennis*, *P. montanus* and *Rh. meridionalis*. However, other caddisflies appear highly significant in group 2 rather than in group 1 as *H. instabilis*, *L. basalis*, *Rh. nevada*, *H. tessellatus* and others (Table 5). *Hydropsyche* gr. *pellucidula* has high IV-value in groups 3 and 4, being typical from midstreams reaches. Instead, other caddis as *Agapetus* sp., *M. aspersus*, *Rh. munda*, *H. infernalis*, *S. argentipunctellus* and *Stenophylax* sp. are exclusive from a more sedimentary-marl rather than calcareous basins. Midstream reaches with a dominant calcareous geology are significantly composed by *C. marginata*, *H. brevis*, *H. gr. pellucidula*, *H. sp1*, *H. bulbifera*, *O. angustella* and *C. lepida*. Other species present in this group 4 as *Rh. dorsalis* and *Limnephilus* sp. (*guadarramicus* type) are also characteristic from headwaters with similar geology (group 1).

### **Temporal patterns of distribution**

When the effect of seasonality is analyzed using all samples, CCA plot (Figure 8) indicates a change of caddisfly taxa between seasons. Although the four first canonical axes explain only 5.9% of the caddisfly variability, Monte Carlo permutations test indicates that all canonical axes are significant when using seasonality ( $F=1.569$ ,  $p\text{-value}=0.005$ ). Several caddisflies remain present and frequent in all seasons, as for example, most of the *Hydropsychidae*, *Hydroptilidae* and *Polycentropodidae*. Trichopteran associated with some temporary sites as *G. pellucidus* or *Stenophylax* sp. appears present in winter and spring but not in summer. Other *Limnephilidae* (*H. radiatus*, *H. digitatus*, *Chaetopteryx* sp. or *Micropterna* sp. are found in spring samples. Summer and autumn seasons have few exclusive caddisfly, with some *Brachycentridae* and *Psychomyiidae*. Instead, many exclusive caddisfly are present between autumn and winter.

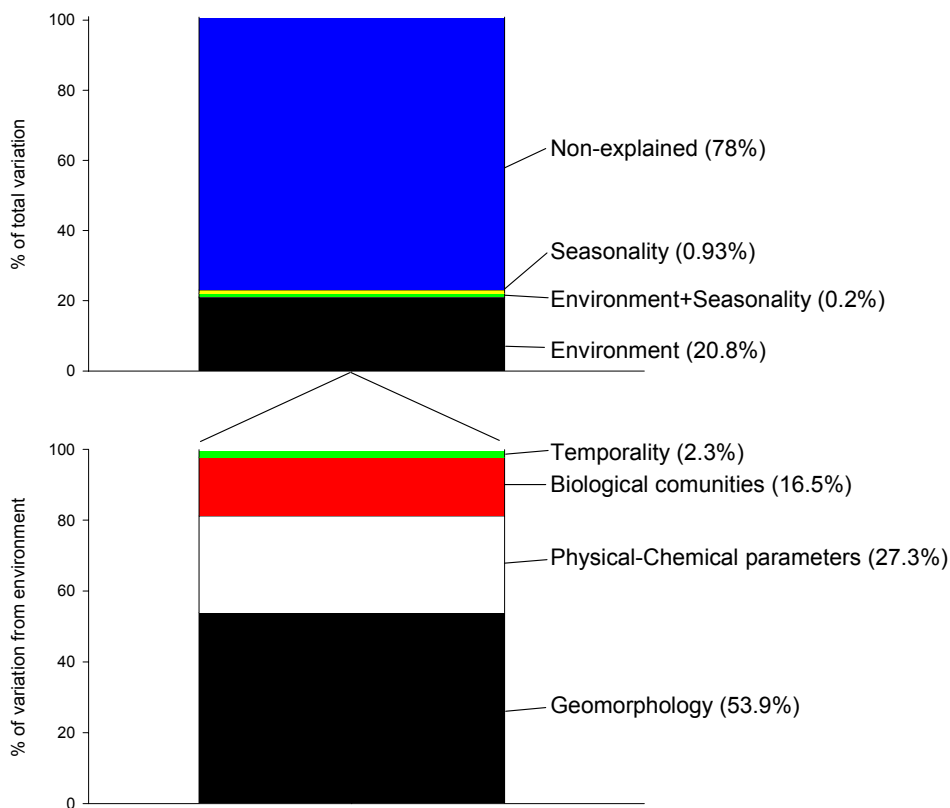




**Figure 8.** CCA plot representing taxa distribution in first ( $X_1$ ) and second ( $X_2$ ) axis using seasonality.

### Relative effect of variables in caddisfly distribution

The variance partition results (Figure 9) indicate that environmental variables explain 20.8% of caddisfly distribution. From those, geomorphological features are the responsible of the major part of environmental variability (53.9%), followed by a mix of physical-chemical and biological community's characteristics. Temporality presents a low percentage explaining caddisfly communities. On the other hand, although significant, only 0.93% of trichoptera variation is explained by the seasonal effect. Interaction between environment and seasonality has also a weak importance in caddisfly distribution (0.2%). A high percentage of unexplained variables are noticed (78%).



**Figure 9.** Variance partition with trichoptera data. Top graph present the percentages of all variation explained by environment and seasonality. Bottom graph present the total variation expressed by environment, separated by geomorphology (basin, riparian and habitat characteristics), physical-chemical variables, biological communities (IBMWP and IASPT) and temporality.

## DISCUSSION

Observed patterns in caddisfly distribution in the Iberian Mediterranean area are spatial and temporal heterogeneous. Consequently, our results agree with the idea that distribution areas are dynamic structures (Antúnez & Mendoza, 1992), and they should be studied in a spatial-

temporal framework using sets of multi-scale factors (Poff, 1997). Large-scale spatial filters (e.g., altitude) can change under large scale temporal ones (i.e., geological time). Instead, local scale features (e.g., discharge) are subjected to different temporal scales (i.e., from geological time to seasonality). All this assumption is very important in areas where climate is highly variable along and between years affecting discharge patterns and macroinvertebrate communities, as for example in mediterranean areas (McElravy *et al.*, 1989). For example, in other mediterranean areas (e.g., in southwestern Australia), macroinvertebrate community in permanent rivers has been found more persistent over time than temporary reaches (Bunn, 1995). In our study seasonality appears significant but only represents 0.93% of all caddisfly variability. Caddisfly larvae are more diverse between autumn, winter and spring than in summer, what may be explained by a high emergence of caddisfly species between June and September (e.g., Waringer, 1989). Most of the Hydropsychids are present in all seasons, except for the infrequent *H. tibialis* and *H. fontinalis*, and *H. infernalis* and *C. lepida* more abundant between autumn and winter (Gallardo-Mayenco *et al.*, 1998). Other taxa, as *M. aspersus* that present some summer strategies to avoid drought (Bouvet, 1974) is absent in summer period and very abundant between winter and spring.

In large scale studies performed in other areas in the world, geomorphological and other large-scale variables (e.g., climate) have been considered the major responsible of macroinvertebrate distribution (e.g., Ross, 1963; Corkum, 1989). However, this phenomenon has been related with the presence of a highly variable landscape and topography in the sampling area (Kay *et al.*, 1999; Wiberg-Larsen *et al.*, 2000). Mediterranean area has an abrupt topography (Conacher & Sala, 1998, Grove & Rackham, 2001) and landscape variables may play an important role structuring communities (Bonada *et al.*, Chapter 3). Trichoptera in Mediterranean Iberian coast is organized according to several variables acting at different scales in a hierarchical way. Geomorphological and landscape features (e.g., altitude, geology) are important to explain caddisfly distributions followed by reach (e.g., channel width, stream order, conductivity, riparian structure), habitat (e.g., riffles vs. pools, substrate diversity, heterogeneity elements) and biological characteristics. Overall, five different caddisfly communities defined by longitudinal zonation and geology (headwaters-midstreams-lowland and siliceous-calcareous-sedimentary reaches) have been established. Responses to caddisfly to these characteristics can be explained by feeding habits (Loudon & Alstad, 1990; Voelz & Ward, 1992), food quality (Petersen, 1987), metabolic needs (Hildrew & Edington, 1979), physical factors (Higler & Tolkamp, 1983; Tachet *et al.*, 1992) and chemical tolerance by natural (geology) (de Moor, 1992) or human-induced characteristics (Gallardo-Mayenco *et al.*, 1998; Stuijzand *et al.*, 1999).

Geology has been considered as an important factor implied in caddisfly patterns and diversity in other areas (e.g., in South Africa —de Moor, 1992). In our case, geology is important to explain a general pattern of caddisfly distribution separating northern basins (mainly calcareous) from intermediate (predominantly sedimentary with marls) and southern ones (mainly siliceous). However, some caddisflies appear independent from geology and more dependent from longitudinal zonation. For example, *P. latipennis*, *Sericostoma* sp., *P. montanus* and *Rh. meridionalis* are shared between siliceous-calcareous headwaters and *H. gr. pellucidula* between calcareous-sedimentary midstreams. Moreover, Zamora *et al.* (1997) found *Rh. meridionalis* in the headwaters of a calcareous river in southeast Spain (Castril river), and Viedma & de Jalón (1980) in a siliceous area in Central Spain. Similarly, the Hydropsychid *H. instabilis* is not restricted to siliceous basins, because it has been collected in calcareous headwaters in southern France (Legier & Talin, 1973), and *Rh. munda* found mostly in sedimentary marls in our area has been collected in siliceous regions (Viedma & de Jalón, 1980; Ruiz *et al.*, 2001).

Traditionally, longitudinal zonation in streams has been related to slope and bed stability, water temperature and current velocity and some other stream hydraulics (see Statzner & Higler, 1986). Several studies have reported changes in macroinvertebrate composition downstream, associated to altitude, stream order, channel width... (e.g., Corkum, 1989; Marchant *et al.*, 1995; Wiberg-Larsen *et al.*, 2000). Marchant *et al.* (1995) suggest that altitude does not affect directly to the macroinvertebrates, but indirectly by changing water temperature, oxygen, discharge, nutrients, and others. In our study, altitude, channel width, stream order and their related variables as conductivity, biological quality, riparian structure, heterogeneity elements... are more important for trichopteran's longitudinal zonation than temperature, discharge or chemical parameters.

Headwater sites in Mediterranean areas (groups 1 and 2) are associated with the highest diverse, exclusive and infrequent caddisfly community, explained by a mix of substrates, heterogeneity elements and riparian structure. In fact, several authors have demonstrated a high correlation between spatial heterogeneity and organisms' diversity (Minshall & Robinson, 1998; Stewart *et al.*, 2000; Lawton, 2000). It is well known the effect of riparian vegetation organizing macroinvertebrate communities in river ecosystems (e.g., Molles, 1982; Aguiar *et al.*, 2002). We found that features directly or indirectly related to riparian forests are essential to explain patterns of some caddisflies species. A well-structured riparian vegetation (i.e., with trees and shrubs) yields a high amount of organic matter to the river beds (Iversen *et al.*, 1982)

that can be retained depending on habitat characteristics (see Molles, 1982). In that sense, Canton & Ward (1981) in a study in a Colorado stream suggest that the absence of some shredders may be related to a decrease of inputs of leaf litter. In our study, the shredders and woody-cased (at least in some instars) caddisflies *L. guadarramicus*, *Halesus* sp., *Chaetopteryx* sp., *G. pellucidus* and *Potamophylax* sp. have been found significantly present in reaches with high riparian structure and heterogeneity elements (groups 1 and 5). These species disappear with increasing aridity (e.g., in Segura, Almanzora and Aguas basins (group 3)) where a high riparian structure and few heterogeneity elements may be related to the presence of a sclerophyllous and evergreen riparian forest. For example, Aguiar *et al.* (2002) in a study in a Portuguese basin under a mediterranean climate, found a positive relationship between ashes (*Fraxinus angustifolia*) and alders (*Alnus glutinosa*) with shredders but not with some sclerophyllous species. However, comparing caddisfly communities between deciduous and evergreen forests, Molles (1982) found a dominance of shredders in coniferous areas because habitat let a more retention of detritus.

Variables associated to the ecological river status (e.g., IBMWP, IASPT, riparian structure) also appear as discriminant variables between groups of sites with different caddisfly structure. Because the high diversification of Trichoptera (Mackay & Wiggins, 1979; Wiggins, 1984), they have been considered as a good indicators of water quality (Resh, 1992; de Moor, 1999; Stuijzand *et al.*, 1999; Berlin & Thiele, 2002; Dohet, 2002; Waringer & Graf, 2002). *Hydropsyche exocellata* have been found in severe polluted sites in many studies (e.g., Higler & Tolkamp, 1983; Gallardo-Mayenco *et al.*, 1998) occupying lowland reaches (e.g., García de Jalón, 1986; Usseglio-Polatera, 1992), whereas *H. gr. Pellucidula*, *C. lepida* and the philopotamid *C. marginata* seem less tolerant to pollution appearing in middle reaches (Usseglio-Polatera, 1992; Moog & Chovarec, 2000; Bonada *et al.*, Chapter 8), what agree with our study. However, in midstreams from sedimentary-marl basins, a very distinct assemblage is found with *M. aspersus*, *Rh. munda*, *H. infernalis* and *S. argentipunctellus* as a dominant species, what enhance the importance of these areas (called Ramblas) as ecological ecosystems (Moreno *et al.*, 1996; 2001). On the other hand, some of these species have been found in other reaches, as *S. argentipunctellus* recorded in upstream reaches over 1860 m in some Morocco streams (Guidicelli *et al.*, 1985), or *H. infernalis* that in the Iberian Peninsula has been recorded and in some headwaters (Gallardo-Mayenco *et al.*, 1998) sometimes over 1000 m (Zamora-Muñoz *et al.*, 1995). Overall, longitudinal patterns displayed by Hydropsychidae correspond to the ones found in Duero Basin by García de Jalón (1986).

Although the large set of variables used a great amount of non-explained variability of species patterns is noticed. Around 74% of all collected caddisfly can be considered rare taxa (present in less than 5% of samples), which is common in macroinvertebrate communities' surveys (Lenat & Resh, 2001). Austin & Greig-Smith (1968) found that the percentage of variability explained in principal components analysis decreased with increasing the number of rare taxa included. In literature, disagreements exist in considering the use of rare taxa especially from a bioassessment point of view (Marchant, 1999; Cao & Williams, 1999; Cao *et al.*, 2001; Lenat & Resh, 2001). According to Cao *et al.* (2001), it is unlikely that rare caddisfly species respond to large-scale variables, but to local factors. For example, in our study, the infrequent *Calamoceras marsupus* is not an indicator caddisfly of any group of sites, although it appears related to several riparian features in the pCCA.

However, some other unconsidered factors may be important to understand this unexplained caddisfly patterns. Interactions between organisms have been considered to play an important role on the macroinvertebrate distribution in space and time (see Power *et al.*, 1988), but because they act in a smaller scale than abiotic processes, only can be detected if environment allow the presence of such organisms (Poff, 1997). Moreover, in a competition study in *Helicopsyche borealis* in a northern California creek, Lamberti *et al.*, (1987) suggested that a limitation on periphiton is the responsible of the intraspecific competition showed by larvae. Consequently, abiotic factors in a direct or indirect way acting at larger scales may be more important than biotic processes in structuring organism's patterns.

Historical factors have been widely neglected in ecological studies, although they have been considered one of the major factors affecting caddisfly distribution in other areas (de Moor, 1992). Iberian Mediterranean coast has been subjected to remarkable geological changes affecting present organism's distribution (Balletto & Casale, 1989). Probably, the most important phenomena were the incorporation of the Baetic-Riffian massif (the present south and south-east of Iberian Peninsula) to the Hesperico Massif, with the Alborán Plate rising at the end of Miocene (Martín-Piera & Sanmartín, 1999). Although the interchange of species with this new area was possible, nowadays a differentiation between southern and northern caddisfly in Iberian Peninsula is still noticed with a high component of North African species in the south and European ones in the north (González *et al.*, 1987; Ruiz *et al.*, 2001). This phenomenon could be the responsible to the mix of northern and southern species in Segura basin, yielding the highest taxa richness. Moreover, this historical factor also may play a significant role in explaining distribution of some caddisfly when samples from Pyrenees and Sierra Nevada (with similar environmental conditions) are compared. For example, several

*Rhyacophila* sp. are widely distributed in calcareous and siliceous headwaters in Pyrenees (e.g., *Rh. tristis*, *Rh. relictata*, *Rh. dorsalis*) but absent in Sierra Nevada. Contrarily, other species are exclusive from southern areas as *H. infernalis* or *Rh. nevada*, although this last one has been considered as a subspecies of *Rh. dorsalis* recently by Malicky (2002).

Organism's distribution is more or less heterogeneous at different spatial-temporal scales of observation (Kolasa & Rollo, 1991; Stewart *et al.*, 2000). When descriptions of distribution patterns are done at large scales to understand general processes implied, a loss of detail and some error have to be assumed (Levin, 1992) because patterns observed at larger scales might not correspond to others at small scale (Minshall, 1988). Results obtained here have inherent this assumption. Overall, caddisfly distribution in the Iberian Mediterranean area responds to longitudinal zonation factors and geological characteristics. However, geology is not as relevant for some caddisfly as zonation variables are, yielding an error in understanding general distribution patterns. A trade-off between all measured descriptors allow us to understand general patterns of distribution of all trichopteran assemblages, whereas some specific taxa distribution can respond to other regional or local factors as history or even random mechanisms (e.g., adult dispersion) and be independent of some general processes.

## REFERENCES

- AGUIAR, F. C., M. T. FERREIRA & P. PINTO. (2002). Relative influence of environmental variables on macroinvertebrate assemblages from an Iberian basin. *J. N. Am. Benthol. Soc.*, 21: 43-53.
- ALBA-TERCEDOR, J. & A. SÁNCHEZ-ORTEGA. (1988). Un método rápido y simple para evaluar la calidad biológica de las aguas corrientes basado en el de Hellawell (1978). *Limnética*, 4: 51-56.
- ALBA-TERCEDOR, J.; GONZÁLEZ, G. & PUIG, M. A. (1992). Present level of knowledge regarding fluvial macroinvertebrate communities in Spain. *Limnética*, 8: 231-241.
- ALBA-TERCEDOR, J. 1996. Macroinvertebrados acuáticos y calidad de las aguas de los ríos. *IV Simposio sobre el Agua en Andalucía*, II: 203-213.
- ALBA-TERCEDOR, J. & PUJANTE, A. 2000. Running-water biomonitoring in Spain. Opportunities for a predictive approach. In: Wright, J.F., Sutcliffe, & Furse, M., (eds.). *Assessing the Biological Quality of Freshwater: RIVPACS and similar techniques*. Freshwater Biological Association. 207-216pp.
- ALLEN, T. F. H. & HOEKSTRA, T. W. (1991). Role of heterogeneity in scaling of ecological systems under analysis. In: Kolasa, J. & Pickett, T. A. (eds.). *Ecological heterogeneity*. Ecological studies, 86. Springer-Verlag. New York. 47-68pp.
- ANTÚNEZ, A. & MENDOZA, M. (1992). Factores que determinan el área de distribución geográfica de las especies: conceptos, modelos y métodos de análisis. *Monogr. Herpetol.*, 2: 51-72.

- AUSTIN, M. P., & GREIG-SMITH, P. (1968). The application of quantitative methods to vegetation survey: some methodological problems of data from rain forests. *J. Ecol.* 56:827-844.
- BALL, I. R. (1975). Nature and formulation of Biogeographic hypothesis. *Syst. Zool.*, 24: 407-430.
- BALLETTO, E. & CASALE, A. (1989). Mediterranean insect conservation. In: Collins, N. M. & Thomas, J. A. *The conservation of insects and their habitats*. Harcourt Brace Jovanovich Publishers. 450pp.
- BERLIN, A. & THIELE, V. (2002). Trichoptera in assessment and classification of streams in the lowlands of north-eastern Germany. *Proc. 10<sup>th</sup> int. Symp. Trichoptera — Nova Suppl. Ent.*, 15: 481-490.
- BOCARD, D.; LEGENDRE, P. & DRAPEAU, P. (1992). Partialling out the spatial component of spatial variation. *Ecology*, 73: 1045-1055.
- BONADA, N.; PRAT, N.; MUNNÉ, A.; RIERADEVALL, M.; ALBA-TERCEDOR, J.; ÁLVAREZ, M.; AVILÉS, J.; CASAS, J.; JÁIMEZ-CUÉLLAR, P.; MELLADO, A.; MOYÀ, G.; PARDO, I.; RAMÓN, G.; SUÁREZ, M. L.; TORO, M.; VIDAL-ABARCA, M. R.; VIVAS, S. & ZAMORA-MUÑOZ, C. (in press).  
 a. Ensayo de una tipología de las cuencas mediterráneas del proyecto guadalmed1 siguiendo las directrices de la directiva marco del agua. *Limnética*.  
 b. Criterios para la selección de condiciones de referencia en los ríos mediterráneos. Resultados del proyecto guadalmed1. *Limnética*.
- BOUVET, Y. (1974). Ecologie et reproduction chez les trichoptères cavernicoles du groupe de stenophylax (limnephilidae, stanophylacini). *Proc. 1<sup>th</sup> Int. Symp. Trichoptera*; 105-109.
- BUNN, S. T. (1995). Biological monitoring of water quality in australian: Workshop summary and future directions. *Aust. J. Ecol.*, 20: 220-227.
- CAMARGO, J. A. & GARCÍA DE JALÓN, D. (1988). Principales características morfológicas de los géneros ibéricos de la familia Limnephilidae (Trichoptera), en sus últimos estadios larvarios. *Bol. Asoc. esp. Entom.*, 12: 239-258.
- CANTON S. P. & WARD, J. V. (1981). The aquatic insects, with emphasis on Trichoptera, of a Colorado stream affected by coal strip-mine drainage. *The Southwestern Naturalist*, 25(4): 453-460.
- CAO, Y.; LARSEN, D. P. & THORNE, R. ST. J. (2001). Rare species in multivariate analysis for bioassessment: some considerations. *J. N. Am. Benthol. Soc.*, 20(1): 144-153.
- CARTER, J. L.; FEND, S. V. & KENNELLY, S. S. (1996). The relationships among three habitat scales and stream benthic invertebrate community structure. *Freshwat. biol.*, 35: 109-124.
- CHURCH, M. (1996). Channel morphology and typology. In: Petts, G. & Callow, P. (eds.). *River flows and channel forms*. Blackwell Science. Oxford. 185-202pp.
- CONACHER, A. J. & SALA, M. (1998) *Land degradation in Mediterranean environments of the world: Nature and extent cause and solutions*. John Wiley & Sons. 491 pp.
- CORKUM, L. (1989). Patterns of benthic invertebrate assemblages in rivers of northwestern North America. *Freshwat. Biol.*, 21: 191-205.
- CORNELL, H. V. & LAWTON, J. H. (1992). Species interactions, local and regional processes, and limits to the richness of ecological communities: A theoretical perspective. *J. Anim. Ecol.*, 61: 1-12.
- CUFFNEY, T. F.; COLES, J. F.; GIDDINGS, E. M.; ZAPPPIA, H. (2002). *Comparison of methods for resolving taxonomic ambiguities in invertebrate data sets*. N. Am. Benthol. Soc. Annual Meeting. Pittsburgh, Pennsylvania. Poster communication.
- CZCHOROWSKI, S. (1994). Classification of small water bodies on the basis of the presence of caddisflies. *Ekol. Pol.*, 42(1-2): 41-59.
- DAGET, PH.; AHDALI, L. & DAVID, P. (1988). Mediterranean bioclimate and its variation in the Palearctic region. In: Specht, R. L. (ed.). *Mediterranean-type ecosystems: A data source book*. Kluwer Academic Publishers. Dordrecht. 248pp.



- DE MOOR, F. C. (1999). The use of Trichoptera to assess biodiversity and conservation status of South African river systems. *Proc. 9<sup>th</sup> Int. Symp. Trichoptera*: 237-244.
- DE MOOR, F. C. (1992). Factors affecting the distribution of Trichoptera in South Africa. *Proc. 7<sup>th</sup> Int. Symp. Trichoptera*: 51-58.
- DOHET, A. (2002). Are caddisflies an ideal group for the biological assessment of water quality in streams? *Proc. 10<sup>th</sup> Int. Symp. Trichoptera — Nova Suppl. Ent.*, 15: 507-520.
- DUFRENE, M. & LEGENDRE, P. (1997). Species assemblages and indicator species: the need for a flexible asymmetrical approach. *Ecological Monographs* 67:345-366.
- ENDLER, J. A. (1982). Problems in distinguishing historical from ecological factors in biogeography. *Amer. Zool.*, 22: 441-452.
- EUROPEAN PARLIAMENT AND THE COUNCIL (2000). *Establishing a framework for Community actions in the field of water policy*. PECONS 3639/00.
- FERRÁN-ARANAZ, M. (2001). *SPSS para Windows. Análisis estadístico*. McGraw Hill/Interamericana de España. Madrid. 421pp.
- FRISSELL, C. A.; LISS, W. J.; WARREN, C. E. & HURLEY, M. D. (1986). A hierarchical framework for stream habitat classification: viewing streams in a watershed context. *Environmental Management*, 10(2): 199-214.
- GALLARDO-MAYENCO, A.; PRENDA, J. & TOJA, J. (1998). Spatio-Temporal distribution and ecological preferences of coexisting hydropsychid species (Trichoptera) in two Mediterranean river Basins (S Spain). *Internat. Reg. Hydrobiol.*, 83(2): 123-134.
- GALLARDO-MAYENCO, A. (1993). Macroinvertebrate associations in two basins of SW Spain. *Arch. Hydrobiol.*, 127(4): 473-483.
- GARCÍA DE JALÓN, D. (1986). Los Hydropsychidae (Trichoptera) de la cuenca del Duero. *Bol. Asoc. esp. Entom.*, 10: 127-138.
- GASITH, A. & RESH, V. H. (1999). Streams in Mediterranean climate region: Abiotic influences and biotic responses to predictable seasonal events. *Annu. Rev. Ecol. Syst.* 30: 51-81.
- GONZÁLEZ, M. A.; GARCÍA DE JALÓN, D. & TERRA, L. (1987). Faunistic studies on Iberian Trichoptera: A historical survey and present state of knowledge. *Proc. 5<sup>th</sup> Int Symp. Trichoptera*: 85-90.
- GONZÁLEZ, M. A. & RUIZ, A. (2001). Une nouvelle espèce de Trichoptère du Sud de l'Espagne: *Allogamus gribaltaicus* n. Sp. (Trichoptera: Limnephilidae). *Ann. Limnol.*, 37(3): 219-221.
- GRAÇA, M. A. S.; FONSECA, D. M. & CASTRO, S. T. (1989). The distribution of macroinvertebrate communities in two Portuguese rivers. *Freshwat. Biol.*, 22: 297-308.
- GROVE, A. T. & RACKHAM, O. (2001). *The nature of mediterranean europe*. Yale University Press, New Haven & London. 384 pp.
- GIUDICELLI, J.; DAKKI, M. & DIA, A. (1985). Caractéristiques abiotiques et hydrologiques des eaux courantes méditerranéennes. *Verh. Internat. Verein. Limnol.*, 22: 2094-2101.
- HERRANZ, J. M. & GARCÍA DE JALÓN, D. (1984). Distribución de las especies del género *Hydropsyche* (o. Trichoptera, Hydropsychidae) en la cuenca del alto tajo (Guadalajara). *Limnética*, 1: 203-206.
- HIGLER, L. W. G. & TOLKAMP, H. H. (1983). Hydropsychidae as bio-indicators. *Enviro. Monit. Assess.*, 3: 331-341.
- HILDREW, A. G. & EDINGTON, J. M. (1979). Factors facilitating the coexistence of hydropsychid caddis larvae (Trichoptera) in the same river system. *J. Anim. Ecol.*, 78: 557-576.
- HOLT, R. D. (1993). Ecology at the mesoscale: the influence of regional processes on local communities. In: Ricklefs, R. E. & Schluter, D. (eds.). *Species diversity in ecological communities: historical and geographical perspectives*. University of Chicago Press. Chicago. 77-88pp.
- IVERSEN, T. M.; THORUP, J. & SKRIVER, J. (1982). Inputs and transformation of allochthonous particulate organic matter in a headwater stream. *Holarctic Ecology*, 5: 10-19.
- JÁIMEZ-CUÉLLAR, P.; VIVAS, S.; BONADA, N.; ROBLES, S.; MELLADO, A.; ÁLVAREZ, M.; ALBA-TECEDOR, J.; AVILÉS, J.; CASAS, J.; ORTEGA, M.; PARDO, I.; PRAT, N.;

- RIERADEVALL, M.; SÁINZ-CANTERO, C.; SÁNCHEZ-ORTEGA, A.; SUÁREZ, M. L.; TORO, M.; VIDAL-ABARCA, M. R. & ZAMORA-MUÑOZ, C. (IN PRESS). Protocolo GUADALMED (PRECE). *Limnetica*.
- KAY, W. R.; SMITH, M. J.; PINDER, A. M.; MCRAE, J. M.; DAVIS, J. A. & HALSE, S. A. (1999). Patterns of distribution of macroinvertebrate families in rivers of north-western australia. *Freat. Biol.*, 41: 299-316.
- KAY, W. R.; HALSE, S. A.; SCANLON, M. D. & SMITH, M. J. (2001). Distribution and environmental tolerances of aquatic macroinvertebrate families in the agricultural zone of southwestern australia. *J. N. Am. Benthol. Soc.*, 20(2): 182-199.
- KÖPPEN, W. (1923). *De klimate der Erde*. Bornträger, Berlin. 369 pp.
- KOLASA, J. & ROLLO, C. D. (1991). Introduction: the heterogeneity of heterogeneity: a glossary. In: Kolasa, J. & Pickett, T. A. (Eds.). *Ecological heterogeneity*. Ecological studies, 86. Springer-Verlag. New York. 1-23pp.
- LAMBERTI, G. A. ; FEMINELLA, J. W. & RESH, V. H. (1987). Herbivory and interspecific competition in a stream caddisfly population. *Oecologia*, 73: 75-81.
- LAWTON, J. H. (2000). Concluding remarks: a review of some open questions. In: Hutchings, M. J. ; John, E. A. & Stewart, A. J. A. (eds.). *The ecological consequences of environmental heterogeneity*. Blackwell Science. Oxford. 401-424pp.
- LEGENDRE, P. (1990). Quantitative methods and biogeographic analysis. In: Garbary, D. J. & South, R. G. (eds.). *Evolutionary biogeography of the marine algae of the North Atlantic*. NATO ASI Series, vol. G22. Springer-Verlag. Berlin. 9-34pp.
- LEGENDRE, P. & LEGENDRE, L. (1998). *Numerical ecology*. Developments in environmental modelling 20. Elsevier. The Netherlands. 853pp.
- LEGIER, P. & TALIN, J. (1973). Comparaison de ruisseaux permanents et temporaires de la Provence calcaire. *Annls. Limnol.*, 9(3): 273-292.
- LENAT, D. R. & RESH, V. H. (2001). Taxonomy and stream ecology — The benefits of genus- and species-level identifications. *J. N. Am. Benthol. Soc.*, 20(2): 287-298.
- LEUVEN, R. S. E. W.; VANHEMELRIJK, J. A. M.; Van der Velde, G. (1987). The distribution of Trichoptera in Dutch soft waters differing in pH. *Proc. 5<sup>th</sup> Int. Symp. on Trichoptera*, 359-365.
- LEVIN, S. A. (1992). The problem of pattern and scale in ecology. *Ecology*, 73: 1943-1967.
- LOUDON, C. & ALSTAD, D. N. (1990). Theoretical mechanisms of particle capture: Predictions for Hydropsychid caddisfly distributional ecology. *Am. Nat.*, 135: 360-361.
- LOBO, J. M. (1998). Influencias geográficas, históricas y filogenéticas sobre la diversidad de las comunidades locales: una revisión y algunos ejemplos utilizando Scarabaeoidea coprófagos (Coleoptera: Laparostici). *Boletín de la Asociación española de Entomología*, 21(3-4): 15-31.
- MACKAY, R. J. & WIGGINS, G. B. (1979). Ecological diversity in Trichoptera. *Ann. Rev. Entomol.*, 24: 185-208.
- MALICKY, H. (2002). The sub-specific division of *Rhyacophila dorsalis* Curtis, 1834 and its transitions to *R. nubile* Zetterstedt, 184 (Trichoptera: Rhyacophilidae). *Proc. 10<sup>th</sup> Int. Symp. Trichoptera — Nova Suppl. Ent.*, 15: 149-166.
- MANTEL, N. (1967). The detection of disease clustering and a generalized regression approach. *Cancer Res.*, 27: 209-220.
- MARCHANT, R. (1999). How important are rare species in aquatic community ecology and bioassessment? A comment on the conclusions of Cao *et al.* *Limnol. Oceanogr.*, 44(7): 1840-1841.
- MARCHANT, R.; BARMUTA, L. A. & CHESSMAN, B. C. (1995). Preliminary study of the ordination and classification of macroinvertebrate communities from running waters in Victoria, Australia. *Aust. J. Mar. Freshwat. Res.*, 45: 945-962.
- MARTÍN-PIERA, F. & SANMARTÍN, I. (1999). Biogeografía de áreas y biogeografía de artrópodos holárticos y Mediterráneos. *Biol. SEA*, 26: 535-560.
- McCUNE, B. & MEFFORD, M. J. (1999). *PC-ORD for Windows: Multivariate Analysis of Ecological Data v. 4.20*. MjM Software, Gleneden Beach, Oregon.

- McELRAVY, E. P.; LAMBERTI, G. A. & RESH, V. H. (1989). Year-to-year variation in the aquatic macroinvertebrate fauna of northern California stream. *J. N. Am. Benthol. Soc.*, 8(1): 51-63.
- MELLADO, A.; SUÁREZ, M.L.; MORENO, J.L.; VIDAL-ABARCA, M.R. (2002). Aquatic macroinvertebrate biodiversity in the Segura River basin (S.E. Spain). *Ver. Internat. Verein. Limnol.*, 28:1-6
- MENGE, B. A. & OLSON, A. M. (1990). Role of scale and environmental factors in regulation of community structure. *TREE*, 5(2): 52-57.
- MILLET, X. (1983). Les larves del gènere *Hydropsyche* (Insecta: Trichoptera) a Catalunya. *Taxonomia. Butll. Inst. Cat. Hist. Nat.*, 49 (sec. Zool., 5): 97-103.
- MINSHALL, G. W. (1988). Stream ecosystem theory: a global perspective. *J. N. Am. Benthol. Soc.*, 7(4): 263-288.
- MINSHALL, G. W. & ROBINSON, C. T. (1998). Macroinvertebrate community structure in relation to measures of lotic habitat heterogeneity. *Arch. Hydrobiol.*, 125: 16-38.
- MOLINA, C.; VIDAL-ABARCA, M. R. & SUÁREZ, M. L. (1994). Floods in arid south-east spanish areas: a historical and environmental review. In: Rossi, G. (Ed.). *Coping With Floods*. Kluwer Academic Publishers. The Netherlands: 271-278.
- MOLLES, M. C. (1982). Trichopteran communities of streams associated with aspen and conifer forest: long-term structural change. *Ecology*, 63: 1-6.
- MOOG, O. & CHOVANEC, A. (2000). Assessing the ecological integrity of rivers: walking the line among ecological, political and administrative interest. *Hydrobiologia*, 422/423: 99-109.
- MORENO, J. L.; SUÁREZ, M. L. & VIDAL-ABARCA, M. R. (1996). Valor ecológico de las ramblas como sistemas acuáticos singulares. *Real Sociedad Española De Historia Natural (tomo extraordinario)*: 411-414.
- MORENO, J. L.; VIDAL-ABARCA, M. R. & SUÁREZ, M. L. (2001). Ecosistemas acuáticos de las ramblas murcianas. *Quercus*, 184: 28-33.
- MUNNÉ, A., SOLÀ, C., y PRAT, N. (1998). QBR: Un índice rápido para la evaluación de la calidad de los ecosistemas de ribera. *Tecnología del Agua*, 175: 20-37.
- MUNNÉ, A., PRAT, N., SOLÀ, C., BONADA, N., & RIERADEVALL, M. (in press). A simple field method for assessing the ecological quality of riparian habitat in rivers and streams. QBR index. *Aquatic Conservation: Marine and Freshwater Ecosystems*.
- MYERS, A. A. & GILLER, P. S. (1988). Process, pattern and scale in biogeography. In: Myers, A. A. & Giller, P. S. (eds.). *Analytical biogeography — An integrated approach to the study of animal and plant distributions*. Chapman and Hall. London. 3-12pp.
- ORMEROD, S. J. & EDWARDS, R. W. (1987). The ordination and classification of macroinvertebrate assemblages in the catchment of the river wye in relation to environmental factors. *Freshwat. Biol.*, 17: 533-546.
- PARDO, I.; ÁLVAREZ, M.; CASAS, J.; MORENO, J. L.; VIVAS, S.; BONADA, N.; ALBATERCEDOR, J.; JÁIMEZ-CUÉLLAR, P.; MOYÀ, G.; PRAT, N.; ROBLES, S.; SUÁREZ, M. L.; TORO, M. & VIDAL-ABARCA, M. R. (in press). El hábitat de los ríos mediterráneos. Diseño de un índice de diversidad de hábitat. *Limnética*.
- PASKOFF, R. P. (1973). Geomorphological processes and characteristics land-forms in the Mediterranean Regions of the World. In: Di Castri, F. & Mooney, H. A. (eds). *Mediterranean Type Ecosystems: Origin and structure*. Springer-Verlag, New York. 405 pp.
- PETERSEN, R. C. (1987). Seston quality as a factor influencing trichopteran populations. *Proc. 5th Int. Symp. Trichoptera*: 287-292.
- POFF, N. L. (1992). Why disturbances can be predictable: a perspective on the definition of disturbance in streams. *J. N. Am. Benthol. Soc.*, 11: 86-92.
- POFF, N. L. (1997). Landscape filters and species traits: towards mechanistic understanding and prediction in stream ecology. *J. N. Am. Benthol. Soc.*, 16(2): 391-409.

- POWER, M. E.; STOUT, R. J.; CUSHING, C. E.; HARPER, P. P.; HAUER, F. R.; MATTHEWS, W. J.; MOYLE, P. B.; STATZNER, B. & WAIS DE BADGEN, I. R. (1988). Biotic and abiotic controls in river and stream communities. *J. N. Am. Benthol. Soc.*, 7(4): 456-479.
- PRAT, N. 1993. El futuro de los ríos españoles: secos o contaminados. *Quercus*. Febrero: 22-24
- PRAT, N., RIERADEVALL, M., MUNNÉ, A., SOLÀ, C., & BONADA, N. (1999). *La qualitat ecològica del Llobregat, el Besòs i el Foix. Informe 1997*. Diputació de Barcelona. Àrea de Medi Ambient (Estudis de la Qualitat Ecològica dels Rius, 6). 154 pp.
- PRAT, N., RIERADEVALL, M., MUNNÉ, A., SOLÀ, C., & CHACÓN, G. (1997). *La qualitat ecològica del Llobregat, el Besòs i el Foix. Informe 1996*. Diputació de Barcelona. Àrea de Medi Ambient (Estudis de la Qualitat Ecològica dels Rius, 2). 153 pp.
- PRENDA, J. & GALLARDO, A. (1992). The influence of environmental factors and microhabitat availability on the distribution of an aquatic oligochaeta assemblage in a mediterranean river basin. *Int. Revue Ges. Hydrobiol.*, 77(3): 421-434.
- PRINGLE, C. M.; NAIMAN, R. J.; BRETSCHKO, G.; KARR, J. R.; OSWOOD, M. W.; WEBSTER, J. R.; WELCOMME, R. L.; WINTERBOURN, M. J. (1988). Patch dynamics in lotic systems: the stream as a mosaic. *J. N. Am. Benthol. Soc.*, 7(4): 503-524.
- PUIG, M. A.; BAUTISTA, I.; TORT, M. J. & PRAT, N. (1981). Les larves de trichopteres de la riviere llobregat (catalogne, espagne). distribution longitudinale et relation avec la qualite de l'eau. *Series Entomologica*, 20: 305-311.
- QUINN, J. M. & HICKEY, C. W. (1990). Characterization and classification of benthic invertebrate communities in 88 new zealand rivers in relation to environmental factors. *New Zeal. Journal of Marine And Freshwater Research*, 24:387-409.
- RESH, V. H. (1992). Recent trends in the use of Trichoptera in water quality monitoring. *Proc. 7<sup>th</sup> int. Symp. Trichoptera*, 285-291.
- ROBLES, S.; TORO, M.; NUÑO, C.; AVILÉS, J.; ALBA-TERCEDOR, J.; ÁLVAREZ, M.; ROBLES, S.; CASAS, J.; JÁIMEZ-CUÉLLAR, P.; MELLADO, A.; MUNNÉ, A.; PARDO, I.; PRAT, N.; SUÁREZ, M. L. & VIDAL-ABARCA, M. R. (in press). Descripción de las cuencas mediterráneas seleccionadas en el proyecto GUADALMED. *Limnética*.
- ROSS, H. H. (1963). Stream communities and terrestrial biomes. *Arch. Hydrobiol.*, 59: 235-242.
- RUIZ, A.; SALAMANCA-OCAÑA, J. C. & FERRERAS-ROMERO, M. (2001). Fauna de tricópteros (Insecta:Trichoptera) de cursos de agua que drenan canutos del Parque Natural Los Alcornocales (sur de España). *Boln. Asoc. esp. Ent.*, 25(3-4): 105-120.
- SMITH, M. J., KAY, W. R., EDWARD, D. H. D., PAPAS, P. J., RICHARDSON, K. ST J., SIMPSON, J. C., PINDER, A. M., CALE, D. J., HORWITZ, P. H. J., DAVIS, J. A., YUNG, F. H., NORRIS, R. H., & HALSE, S. A. 1999. AusRivAS: using macroinvertebrates to assess ecological condition of rivers in Western Australia. *Freshwat. Biol.*, 41: 269-282.
- SPSS, INC. (1999). *SPSS for Windows*. Version 10.0.6.
- STATZNER, B. & HIGLER, B. (1986). Stream hydraulics as a major determinant of benthic invertebrate zonation patterns. *Freshwat. Biol.*, 16: 127-139.
- STEWART, A. J. A.; JOHN, E. A. & HUTCHINGS, M. J. (2000). The world is heterogeneous: ecological consequences of living in a patchy environment. In: Hutchings, M. J.; John, E. A. & Stewart, A. J. A. (eds.). *The ecological consequences of environmental heterogeneity*. Blackwell Science. Oxford. 1-8 pp.
- STUIJFZAND, S. C.; ENGELS, S.; VAN AMMELROOY, E. & JONKER, M. (1999). Caddisflies (Trichoptera: Hydropsychidae) used for evaluating water quality of large European rivers. *Arch. Environm. Contam. Toxicol.*, 36: 186-192.
- SUÁREZ, M. L. y VIDAL-ABARCA, M. R. (2000). Aplicación del índice de calidad del bosque de ribera, QBR (Munné *et al.*, 1998) a los cauces fluviales de la cuenca del río Segura. *Tecnología del Agua*, 201: 33-45.
- SUÁREZ, M. L.; VIDAL-ABARCA, M. R.; SÁNCHEZ-MONTOYA, M.; ALBA-TERCEDOR, J.; ÁLVAREZ, M.; AVILÉS, J.; BONADA, N.; CASAS, J.; JÁIMEZ-CUÉLLAR, P.; MUNNÉ, A.; PARDO, I.; PRAT, N.; RIERADEVALL, M.; SALINAS, M. J.; TORO, M. & VIVAS, S. (in

- press.). Las riberas de los ríos mediterráneos y su calidad: El uso del índice QBR. *Limnética*.
- TACHET, H.; PIERROT, J. P.; ROUX, C. & BOURNAUD, M. (1992). Net-building behaviour of six Hydropsyche species (Trichoptera) in relation to current velocity and distribution along the Rhône rRiver. *J. N. Am. Benthol. Soc.*, 11(4): 350-365.
- TER BRAAK, C.J.F. & P. SMILAUER, 1998. *CANOCO Reference Manual and User's Guide to Canoco for Windows : Software for Canonical Community Ordination (version 4)*. Microcomputer Power. Ithaca, NY.
- TORO, M.; ROBLES, S.; AVILÉS, J.; NUÑO, C.; VIVAS, S.; BONADA, N.; PRAT, N.; ALBA-TERCEDOR, J.; CASAS, J.; GUERRERO, C.; JAIMEZ-CUÉLLAR, P.; MORENO, J. L.; MOYÁ, G.; RAMÓN, G.; SUÁREZ, M. L.; VIDAL-ABARCA, M. R. (in press.). Calidad de las aguas de los ríos mediterráneos del proyecto Guadalmed. Características fisico-químicas. *Limnética*.
- TOWNSEND, C. R. (1989). The patch dynamics concept of stream community ecology. *J. N. Am. Benthol. Soc.*, 8(1): 36-50.
- TRABAUD, L. (1981). Man and Fire: Impacts on mediterranean vegetation. In: di Castri, FR.; Goodall, D. W. & Specht, R. W. (eds.). *Mediterranean-Type Shrublands*. Elsevier, New York. 643pp.
- USSEGLIO-POLATERA, P. (1992). Graphical expresión of the ecological significance of a faunistic assemblage and its application to the study of the Rhône river Trichoptera at Lyons (France). *Proc. 7th Int. Symp. Trichoptera*: 305-311.
- VIEDMA, M. & GARCÍA DE JALÓN, D. (1980). Description of four larvae of Rhyacophila (Pararhyacophila) from the Lozoya River, Central Spain, and key to the species of the Iberian Peninsula (Trichoptera: Rhyacophilidae). *Aquatic Insects*, 2(1): 1-12.
- VIEIRA-LANERO, R. (1996). *Contribución al conocimiento de las larvas de algunos Tricópteros (Insecta: Trichoptera) de Galicia*. MSc. Universidad de Santiago de Compostela. 111pp.
- VIEIRA-LANERO, R. (2000). *Las larvas de los tricópteros de Galicia (Insecta: Trichoptera)*. PhD. Universidad de Santiago de Compostela. 611pp.
- VIVAS, S.; CASAS, J. J.; PARDO, I.; ROBLES, S.; BONADA, N.; MELLADO, A.; ALBA-TERCEDOR, J.; ÁLVAREZ, M.; BAYO, M. M.; JAIMEZ-CUÉLLAR, P.; TORO, M.; VIDAL-ABARCA, M. R.; ZAMORA-MUÑOZ, C. & PRAT, N. (in press). Aproximación multivariante en la exploración de la tolerancia ambiental de las familias de macroinvertebrados de los ríos Mediterráneos del proyecto Guadalmed-1. *Limnética*.
- VOELZ, N. A. & WARD, J. V. (1992). Feeding habits and food resources of filter-feeding Trichoptera in a regulated mountain stream. *Hydrobiologia*, 231: 187-196.
- WARINGER, J. A. (1989). The abundance and temporal distribution of caddisflies (Insecta: Trichoptera) caught by light traps on the Austrian Danube from 1986 to 1987. *Freshwat. Biol.*, 21: 387-399.
- WARINGER, J. & GRAF, W. (2002). Trichoptera communities as a tool for assessing the ecological integrity of Danubian floodplains in Lower Austria. *Proc. 10th Int. Symp. Trichoptera — Nova Suppl. Ent.*, 15: 617-623.
- WIBERG-LARSEN, P.; BRODERSEN, K. P.; BIRKHOLM, S.; GRØN, P. N. & SKRIVER, J. (2000). Species richness and assemblage structure of Trichoptera in Danish streams. *Freshwat. Biol.*, 43: 633-647.
- WIENS, J. A.; STENSETH, N. C.; VAN HORNE, B. & IMS, R. A. (1993). Ecological mechanisms and landscape ecology. *Oikos*, 66: 369-380.
- WIGGINS, G. B. (1984). Trichoptera, some concepts and questions. *Proc. 4th Int. Symp. Trichoptera*, 1-12.
- WRIGHT, J. F.; MOSS, D.; ARMITAGE, P. D. & FURSE, M. T. (1984). A preliminary classification of running water sites based on macroinvertebrate species and the prediction of community type using environmental data. *Freshwat. Biol.*, 14: 221-256.
- ZAMORA-MUÑOZ, C.; ALBA-TERCEDOR, J. (1992). Description of the larva of *Rhyacophila (Rhyacophila) nevada* Schmid, 1952 and key to the species of *Rhyacophila* of the Iberian Peninsula (Trichoptera: Rhyacophilidae). *Aquatic Insects*, 14(2): 65-71.





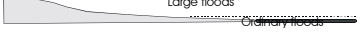


- ZAMORA-MUÑOZ, C.; ALBA-TERCEDOR, J. & GARCÍA DE JALÓN, D. (1995). The larvae of the genus *Hydropsyche* (Hydropsychidae: trichoptera) and key for the identification of species of the Iberian Peninsula. *Bull. Soc. Entomol. Suisse*, 68: 189-210.
- ZAMORA-MUÑOZ, C.; PICAZO, J. & ALBA-TERCEDOR, J. (1997). New findings on the larval pattern variability in *Rhyacophila meridionalis* Pictet, 1865 (Trichoptera: Rhyacophilidae). *Aquatic Insects*, 19(1): 1-8.
- ZAMORA-MUÑOZ, C.; GONZÁLEZ, M. A.; PICAZO-MUÑOZ, J. & ALBA-TERCEDOR, J. (2002). *Hydropsyche fontinalis*, a new species of the *instabilis*-group from the Iberian Peninsula (Trichoptera, Hydropsychidae). *Aquatic Insects*, 24(3): 189-197.

## Annex 1. QBR field sheet

QBR INDEX Riparian habitat quality				
<b>SECTION 1: Total riparian cover</b>				Section 1 score
Score				
25	> 80 % of riparian cover (excluding annual plants)			
10	50-80 % of riparian cover			
5	10-50 % of riparian cover			
0	< 10 % of riparian cover			
+ 10	if connectivity between the riparian forest and the woodland is total			
+ 5	if the connectivity is higher than 50%			
- 5	connectivity between 25 and 50%			
- 10	connectivity lower than 25%			
<b>SECTION 2: Cover structure</b>				Section 2 score
Score				
25	> 75 % of tree cover			
10	50-75 % of tree cover or 25-50 % tree cover but 25 % covered by shrubs			
5	tree cover lower than 50 % but shrub cover at least between 10 and 25 %			
0	less than 10% of either tree or shrub cover			
+ 10	at least 50 % of the channel has helophytes or shrubs			
+ 5	if 25-50 % of the channel has helophytes or shrubs			
+ 5	if trees and shrubs are in the same patches			
- 5	if trees are regularly distributed and shrubland is > 50 %			
- 5	if trees and shrubs are distributed in separate patches, without continuity			
- 10	trees distributed regularly, and shrubland < 50 %			
<b>SECTION 3: Cover quality</b> (the geomorphological type should be first determined*)				Section 3 score
Score		Type 1	Type 2	Type 3
25	number of native tree species:	> 1	> 2	> 3
10	number of native tree species:	1	2	3
5	number of native tree species:	0	1	1 - 2
0	absence of native trees	-		
+ 10	if the tree community is continuous along the river and covers at least 75% of the edge riparian area			
+ 5	the tree community is nearly continuous and cover at least 50% of the riparian area			
+ 5	if the riparian community is structured in gallery			
+ 5	when the number of shrub species is:	> 2	> 3	> 4
- 5	if there are some man-made buildings in the riparian area			
- 5	is there is some isolated species of non-native** trees			
- 10	presence of communities of non-native** trees			
- 10	presence of garbage			
<b>SECTION 4: Channel alteration</b>				Section 4 score
Score				
25	unmodified river channel			
10	fluvial terraces modified and constraining the river channel			
5	Channel modified by rigid structures along the margins			
0	channelized river			
- 10	river bed with rigid structures (e.g wells)			
- 10	transverse structures into the channel (e.g weirs)			
<b>Final score</b> (sum of four section scores)				

**\* Type of the riparian habitat (to be applied at level 3, cover quality)**

The score is obtained by addition of the scores assigned to left and right river margins according to their slope. This value can be modified if islands or hard substrata are present.

		<b>Score</b>		
		Left	Right	
<b><i>Slope and form of the riparian zone</i></b>				
Very steep, vertical or even concave (slope > 75°), very high, margins are not expected to be exceeded by floods. <i>Slope is the angle subtended by the line between the top of the riparian area and the edge of the ordinary flooding of the river.</i>			<b>6</b>	<b>6</b>
Similar to previous category but with a bankfull which differentiates the ordinary flooding zone from the main channel.			<b>5</b>	<b>5</b>
Slope of the margins between 45 and 75 °, with or without steps. (a > b)			<b>3</b>	<b>3</b>
Slope between 20 and 45 °, with or without steps. (a < b)			<b>2</b>	<b>2</b>
Slope < 20 °, large riparian zone.			<b>1</b>	<b>1</b>
<b><i>Presence of one or several islands in the river</i></b>				
Width of all the islands "a" > 5 m.				<b>- 2</b>
Width of all islands "a" < 5 m.				<b>- 1</b>
<b><i>Percentage of hard substrata that can make impossible the presence of plants with roots.</i></b>				
	> 80 %			Not applicable
	60 - 80 %			+ 6
	30 - 60 %			+ 4
	20 - 30 %			+ 2
<b><i>Total Score</i></b>				

**Geomorphological type according to the total score**

> 8	<b>Type 1</b>	Closed riparian habitats. Riparian trees, if present, reduced to a small strip. Headwaters.
5 to 8	<b>Type 2</b>	Headwaters or midland riparian habitats. Forest may be large and originally in gallery.
< 5	<b>Type 3</b>	Large riparian habitats, and potentially extensive forests. Lower courses.



## Annex 2. IHF field sheet

Evaluación del Hábitat Fluvial para Ríos Mediterráneos. Índice IHF			
Bloques			Puntuación
<b>1. Inclusión rápidos-sedimentación pozas</b>			
Rápidos	Piedras, cantos y gravas no fijadas por sedimentos finos. Inclusión 0 - 30%.	10	
	Piedras, cantos y gravas poco fijadas por sedimentos finos. Inclusión 30 - 60%.	5	
	Piedras, cantos y gravas medianamente fijadas por sedimentos finos. Inclusión > 60%.	0	
Sólo pozas	Sedimentación 0 - 30%	10	
	Sedimentación 30 - 60%	5	
	Sedimentación > 60%	0	
<b>TOTAL (una categoría)</b>			
<b>2. Frecuencia de rápidos</b>			
	Alta frecuencia de rápidos. Relación distancia entre rápidos / anchura del río < 7	10	
	Escasa frecuencia de rápidos. Relación distancia entre rápidos / anchura del río 7 - 15	8	
	Ocurrencia ocasional de rápidos. Relación distancia entre rápidos / anchura del río 15 - 25	6	
	Constancia de flujo laminar o rápidos someros. Relación distancia entre rápidos/anchura del río >25	4	
	Sólo pozas	2	
<b>TOTAL (una categoría)</b>			
<b>3. Composición del sustrato</b>			
% Bloques y piedras	1 - 10%	2	
	> 10%	5	
% Cantos y gravas	1 - 10%	2	
	> 10%	5	
% Arena	1 - 10%	2	
	> 10%	5	
% Limo y arcilla	1 - 10%	2	
	> 10%	5	
<b>TOTAL (sumar categorías)</b>			
<b>4. Regímenes de velocidad / profundidad</b>			
<i>somero: &lt; 0.5 m</i> <i>lento: &lt; 0.3 m/s</i>	4 categorías. Lento-profundo, lento-somero, rápido-profundo y rápido-somero.	10	
	Sólo 3 de las 4 categorías	8	
	Sólo 2 de las 4	6	
	Sólo 1 de las cuatro	4	
<b>TOTAL (una categoría)</b>			
<b>5. Porcentaje de sombra en el cauce</b>			
	Sombreado con ventanas	10	
	Totalmente en sombra	7	
	Grandes claros	5	
	Expuesto	3	
<b>TOTAL (una categoría)</b>			
<b>6. Elementos heterogeneidad</b>			
Hojarasca	> 10% ó < 75%	4	
	< 10% ó > 75%	2	
	Presencia de troncos y ramas	2	
	Raíces expuestas	2	
	Diques naturales	2	
<b>TOTAL (sumar categorías)</b>			
<b>7. Cobertura de vegetación acuática</b>			
% Plocon + briófitos	10 - 50%	10	
	< 10% ó > 50%	5	
% Pecton	10 - 50%	10	
	< 10% ó > 50%	5	
% Fanerógamas + Charales	10 - 50%	10	
	< 10% ó > 50%	5	
<b>TOTAL (sumar categorías)</b>			
<b>PUNTUACIÓN FINAL (suma de las puntuaciones anteriores)</b>			

**Annex 3.** Taxa's codes

<b>CODE</b>	<b>TAXA</b>
Adic	<i>Adicella</i> sp.
Agap	<i>Agapetus</i> sp.
Allog	<i>Allogamus</i> sp.
Allotr	<i>Allotrichia pallicornis</i>
Anom	<i>Anomalopterygella chauviniana</i>
Drusb	<i>Drusus bolivari</i>
Athrip	<i>Athripsodes</i> sp.
Berae	<i>Beraea</i> sp.
Brachy	<i>Brachycentrus (O.) maculatum</i>
Calam	<i>Calamoceras marsupus</i>
Ceracl	<i>Ceraclea</i> sp.
Chaet	<i>Chaetopteryx</i> sp.
Cheum	<i>Cheumatopsyche lepida</i>
Chima	<i>Chimarra marginata</i>
Cyrnu	<i>Cyrnus</i> sp.
Ecnom	<i>Ecnomus</i> sp.
Gloss	<i>Glossosoma</i> sp.
Glyph	<i>Glyphotaelius pellucidus</i>
Haldi	<i>Halesus digitatus</i>
Halra	<i>Halesus radiatus</i>
Haltes	<i>Halesus tessellatus</i>
Hypsbr	<i>Hydropsyche brevis</i>
Hypsbu	<i>Hydropsyche bulbifera</i>
Hypsfo	<i>Hydropsyche fontinalis</i>
Hypsd	<i>Hydropsyche dinarica</i>
Hypsex	<i>Hydropsyche exocellata</i>
Hypspe	<i>Hydropsyche</i> gr. <i>pellucidula</i>
Hypsinf	<i>Hydropsyche infernalis</i>
Hypsins	<i>Hydropsyche instabilis</i>
Hypssi	<i>Hydropsyche siltalai</i>
Hyps	<i>Hydropsyche</i> sp.
Hypsp1	<i>Hydropsyche sp1</i>
Hypsti	<i>Hydropsyche tibialis</i>
Hydrt	<i>Hydroptila</i> sp.
Ithyt	<i>Ithytrichia</i> sp.
Lasio	<i>Lasiocephala basalis</i>

<b>CODE</b>	<b>TAXA</b>
Limne	<i>Limnephilus</i> sp. ( <i>guadarramicus</i> )
Lype	<i>Lype reducta</i>
Meso	<i>Mesophylax aspersus</i>
Metal	<i>Metalype fragilis</i>
Micrlon	<i>Micrasema longulum</i>
Micrmin	<i>Micrasema minimum</i>
Micrmo	<i>Micrasema moestum</i>
Mysta	<i>Mystacides azurea</i>
Odont	<i>Odontocerum albicorne</i>
Ortho	<i>Orthotrichia angustella</i>
Oxyet	<i>Oxyethira</i> sp.
Philo	<i>Philopotamus montanus</i>
Plect	<i>Plectrocnemia</i> sp.
Polyc	<i>Polycentropus</i> sp.
Potcin	<i>Potamophylax cingulatus</i>
Potlat	<i>Potamophylax latipennis</i>
Psychct	<i>Psychomyia</i> cf. <i>ctenophora</i>
Psychpu	<i>Psychomyia pusilla</i>
Rhycm	<i>Rhyacophila</i> cf. <i>munda</i>
Rhyocc	<i>Rhyacophila</i> cf. <i>occidentalis</i>
Rhytri	<i>Rhyacophila</i> gr. <i>tristis</i>
Rhydor	<i>Rhyacophila dorsalis</i>
Rhyfas	<i>Rhyacophila fasciata denticulata</i>
Rhymer	<i>Rhyacophila meridionalis</i>
Rhymun	<i>Rhyacophila munda</i>
Rhynev	<i>Rhyacophila nevada</i>
Rhyrel	<i>Rhyacophila relicta</i>
Rhysp	<i>Rhyacophila</i> sp.
Seric	<i>Sericostoma</i> sp.
Setod	<i>Setodes argentipunctellus</i>
Steno	<i>Stenophylax</i> sp.
Synag	<i>Synagapetus</i> sp.
Tinosp	<i>Tinodes</i> sp.
Tinowae	<i>Tinodes waeneri</i>
Worml	<i>Wormaldia</i> sp.