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Distribution of Trichoptera Communities in the Hozgarganta Catchment (Los Alcornocales Natural Park, SW Spain)

key words: caddisflies, conductivity, temperature, SW Spain

Abstract

The distribution of Trichoptera of the Hozgarganta River (Los Alcornocales Natural Park, SW Spain) in relation with environmental factors was examined.

Three groups of species were recognised according to the altitudinal gradient. In the headwaters the caddisflies *Rhyacophila fonticola*, *Lepidostoma hirtum*, *Silonella aurata*, *Allogamus gibraltarius*, *Hydropsyche infernalis* and *Diplectrona felix* predominated; in the constrained section of the tributaries *Polycentropus kingi*, *Chimarra marginata*, *Hydropsyche iberomaroccana*, *R. fonticola* and *Tinodes* sp. prevailed; finally, in the main channel *H. iberomaroccana*, *C. marginata*, *Hydropsyche lobata*, *Leptocerus lusitanicus* and *Rhyacophila munda* were the most important species. A direct ordination analysis (CCA) was used to describe assemblage changes among sites and corroborated that conductivity and temperature were the variables that best explained Trichoptera distribution.

The temporal analysis showed changes in the Trichoptera diversity and richness in permanent stretches, as well as variations in the structure of the communities according to the season. We identified autumn-winter species (*H. infernalis*, *H. siltalai*, *H. lobata*, *R. fonticola* and *R. munda*) and summer ones (*Ithytrichia* sp., *Oxyethira unidentata*, *Mystacides azurea* and *Setodes argentipunctellus*). In the basin we distinguished permanent, intermittent and ephemeral reaches with similar caddisfly richness and diversity, however the species composition associated with each one was different.

1. Introduction

The Trichoptera constitute one of the main groups of the fluvial benthos. They can live under a wide range of ecological conditions and are able to reside in a great number of habitats. The high diversity of the group is interpreted as an expression of the great ecological opportunities offered by the secretion of silk of the caddisfly larvae, thus they have developed a series of complex adaptive systems in order to use a variety of resources (MACKAY and WIGGINS, 1979). Moreover, they are essential to understand the functioning of the aquatic communities.

There are very few studies carried out on the ecology of fluvial macroinvertebrates in this area of the Iberian Peninsula (GALLARDO-MAYENCO, 1991, 1993, 1994; GALLARDO-MAYENCO *et al.*, 1998; GARCÍA DE JALÓN and GONZÁLEZ DEL TÁNAGO, 1986; RUIZ, 2000). The interest of the study of these insects in the basin of the Hozgarganta River is evident. This river basin has Mediterranean conditions with an Atlantic influence and special biogeographical

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characteristics due to the proximity of North Africa. On the other hand, the Hozgarganta River is one of the few non regulated rivers in Spain and, besides, in a good state of conservation. The objective of this work is to increase the knowledge of the ecological requirements and biogeographical aspects of the Trichoptera species in Southern Spain.

2. Study Area and Method

The Hozgarganta River basin covers a surface of 245 km² and it extends in a NW–SE direction (Fig. 1). The system drains the Eastern slopes of the mountain range of the Aljibe and after 55 km the watercourse joins the Guadiaro River, near its mouth (BLANCO *et al.*, 1991).

The studied area includes the total river basin within the limits of the Los Alcornocales Natural Park. The river source is at 160 m a. s. l., in the confluence of the Pasada Blanca canyon and the La Saucedá gorge. The first one flows through calcareous lands and the second one through the Aljibe area (dominated by sandstone with marl and clay). The study area is covered by indigenous Mediterranean forests, in which the cork oak (*Quercus suber*) dominates. Other common species are the Andalusian gall oak (*Quercus canariensis*) and the wild olive (*Olea europaea*). In the humid and shaded canyons there are relicts of the subtropical forest from tertiary age (e.g. *Laurus nobilis*, *Rhododendrum ponticum*) and an arboreal stratum of alder-trees (*Alnus glutinosa*), willows (*Salix atrocinerea*, *Salix pedicellata*) and ash-trees (*Fraxinus angustifolia*) (JURADO-DOÑA, 2002). In this basin, land is mostly used for cork oak forest exploitation and extensive ranching.

Seventeen sampling sites were chosen, four in the main channel of the river and the rest on the tributaries (Fig. 1). Station 7, which did not contain caddisflies, has not been considered in the study.

Expeditions were carried out to take samples during November (1996), February, March, April, June, August, October and December of 1997. The sampling was organised in four visits. In the first visit

Figure 1. Location of the study area and sampling sites. Number codes are explained in Table 1.

samples in all the selected localities were gathered; in the following ones sites 15, 9 and 12 were sampled. In order to have a more complete vision of the fauna that inhabits the river basin we have taken into account later samplings from headstreams (1999–2000). In particular, we have selected “canutos” del Moral, Molino de las Cuevas and el Moro. For the extraction of the entomofauna we took three replicates at each site using a kick net (0.3×0.3 m opening and 0.5 mm mesh size) in approximately 15 minutes. Samples were set to cover all major microhabitats and they were fixed using alcohol at 70%, and later analysed in the laboratory.

Water samples were taken for chemical characterisation in February (winter), June (spring), August (summer) and December (autumn). The average values of the analysed parameters are shown in Table 1.

A Canonical Correspondence Analysis (CCA) with all data was performed. In order to determine the statistical meaning of the groups of sites identified in the CCA, k-mean cluster analysis according to their first axis scores was performed. Three groups of stations were established a priori. The environmental characterisation of the sites was carried out using a Discriminant Analysis (step by step) by the forward selection method with $F = 0.05$. Finally, the indicator value (IV) for the species was obtained (for more details see BONADA, 2003).

A second CCA with seasonal abundance data to study the changes in the communities throughout the year was performed. Richness, diversity and abundance in the different sites and season were analysed using the Kruskal-Wallis test. The differences in the communities were calculated by MRPP Analysis (Multi-Response Permutation Procedure). Previously, all variables were log-transformed.

3. Results

3.1. Environmental Features of the River System

The conductivity values were very elevated in the gorge of La Saucedá (Table 1). This is a consequence of an outcrop of Triassic materials that occurs in the area which a wide stretch of this gorge runs. In spite of the dilution that takes place downstreams, the values reached in Diego Duro and Las Cañillas are still elevated: up to 1.007 and 814 $\mu\text{S}/\text{cm}$, respectively. Also the concentrations of phosphates, ammonium and nitrates in these sections were appreciable (Table 1): they may be due to a cattle farm and to waste from a little village nearby. Nevertheless, these levels are very low suggesting there is not organic pollution or significant alterations derived from this activity.

3.2. Geomorphological Gradient and Trichoptera Species

The CCA performed from global data show that the total variance („inertia“) was 4.93, in the procedure three canonical axes were obtained. The Monte Carlo test indicated that all canonical axes were significant ($P = 0.045$ for axes 1 and 2 and $P = 0.035$ for axis 3). The first axis explained 16.3% of data variance; the second one 10.5% and the third one only 7.8%. The cumulative variance was 34.6%. After the comparison with a correspondence analysis we obtained that the variables strongly correlated with the first axis (temperature: $r = -0.91$; conductivity: $r = -0.885$; chloride: $r = -0.875$; Alkalinity: $r = -0.724$; altitude: $r = 0.807$) explained 94.1% of its variance; variables correlated with the second axis 62.9% and the correlated ones with third axis 62.2% of its variation respectively. A high percentage of unexplained variance was noticed (65.4%).

Figure 2 shows sites and species distributed in the plane formed by axes 1 and 3. The first axis represents the geomorphological gradient and placed the stations from the right to left according to altitude, mineralization and water temperature, which corresponded to a salinity-thermal axis (VIVAS *et al.*, 2002). We differentiated three groups of stations: headwater streams, represented by Eml, Emc and Em; a second group constituted by the streams that drain the mountain range of the Aljibe and a third group composed by the stations on the

Table 1. Mean values of the physico-chemical parameters measured in the sampling sites of the Hozgarganta River. * water permanence (Perm.); 1. permanent flow; 2. ephemeral; 3. intermittent (BONADA, 2003). nd: non detectable. Cond: conductivity; Cl⁻: chloride; Alk: alkalinity; O₂: dissolved oxygen; Temp: temperature; Altit: altitude; Order: stream order.

N°	Code	Locality	n	Cond. µS/cm	Cl ⁻ mg/l	Alk meq/l	O ₂ mg/l	Temp. °C	Altit. a. s. l.	Order	Perm. *	NO ₃ ⁻ mg/l	PO ₄ ⁼ µg/l	NH ₄ ⁺ mg/l
1	E1	Diego Duro	4	630	122	2.1	6.7	16.9	155	4	3	0.2	0.8	0.02
2	Ecñ	Puente las Cañillas	4	639	126	1.9	8.5	20.5	145	4	3	0.01	0.4	0.06
3	Eher	Herrunbroso	3	428	83	1.9	9.5	19.1	110	4	2	nd	0.2	nd
4	E2	Jimena de la Frontera	3	249	53	1.5	9.3	20.1	35	4	2	nd	0.2	0.01
5	Epbm	G ^a Pasada Blanca	3	368	53	2.6	5.1	18.1	250	3	3	0.02	0.4	0.01
6	Epbh	G ^a Pasada Blanca	2	433	61	3	5.1	18.2	245	3	3	0.01	0.2	0.03
8	Eo	Garganta de la Balsa	4	168	49	2.1	7.3	16.8	145	1	3	0.005	0.3	0.02
9	Ero	G ^a Pasada Llana	4	148	27	1.4	8.7	16	500	2	3	0.007	0.2	0.02
10	Eca	A° Puente Carnero	2	123	20	1.2	7.8	10.9	360	1	2	nd	nd	nd
11	Esa	Garganta de la Saucedá	4	1605	490	1.9	7.4	18.6	230	3	3	0.005	nd	0.02
12	Edi	A° Diego Duro	3	95	20	1.2	7.7	15.1	320	1	2	nd	nd	nd
13	Ere	A° Reinoso	2	168	25	1.7	8.4	11.8	160	1	2	nd	nd	nd
14	Emo	Garganta de Moracha	3	180	24	1.9	9.7	15.1	170	2	2	nd	nd	nd
15	Ehu	Garganta del Huevo	3	142	26	1.3	9.6	14.4	230	2	2	nd	nd	0.01
16	Ega	Garganta de Gamero	2	326	80	2.5	9.7	19.7	60	2	2	nd	0.5	0.02
17	Evi	A° de las Viñas	3	355	48	2.4	9.3	19.9	50	2	3	0.006	0.3	0.01
18	Em	Canuto del Moro	4	9	1.6	1.2	7.5	12.3	880	1	1	nd	nd	nd
19	Emc	Canuto Molino de las Cuevas	4	12	2.1	1.7	7.8	12.1	800	1	1	nd	nd	nd
20	Eml	Canuto del Moral	4	9	1.7	1.3	8.8	12.4	700	1	1	nd	nd	nd

Figure 2. CCA plot representing samples and taxa distribution according to the first and third axes of the analysis. Ord: stream order. The acronyms of sites are explained in Table 1. Acronyms of species are explained in Table 2.

main channel and their tributaries from the east side. The third axis had less explanatory power and just discriminated the stations of Pasada Blanca from the one located in the Hozgarganta River near Jimena de la Frontera (E2) (Fig. 2). The second axis (not drawn) discriminated the first order stations with permanent flow (Eml, Emc and Em) from the temporary ones (Ere and Eca).

The species distribution was related with the geomorphological gradient. Headwater assemblages (*Diplectrona felix*, *Allogamus gibraltarius*, *Hydropsyche infernalis*, *Lepidostoma hirtum* and *Silonella aurata*) were positioned on the positive end of the axis one; while in the negative end *Hydropsyche iberomaroccana*, *Hydropsyche lobata*, *Chimarra marginata* and *Rhyacophila munda* were located. The third axis separated the main species of the station of Jimena de la Frontera (*Hydropsyche lobata* and *Ecnomus deceptor*) from the more abundant ones in Pasada Blanca (*Ithytrichia* sp. and *Setodes argentipunctellus*).

Figure 3. Result of Discriminant Analysis with the most significant variables between groups. Plots are ordered from top to bottom according to their Wilk's Lambda value in Discriminant Analysis. Code of the X axis: 1. headstream; 2. tributary gorges and 3. main channel of the river.

According to their environmental features three groups of sites were selected in the discriminant analysis (Fig. 3). Group 1 clustered the stations of greater altitude; they are small channels, with fresh water, permanent flow, well oxygenated and with low conductivity. Group 2 included tributary gorges that drains from the mountain range of the Aljibe along with the La Balsa gorge; these sites displayed intermediate values of the selected environmental characteristics. Group 3 included the stations located along of the main channel, Evi, Ega, Epbm and Epbh; they are localities of low altitude, with mineralised water and variable concentration of dissolved oxygen.

The differences in the communities of caddisfly between the three groups of sites were significant according to the MRPP Analysis ($A = 0.119$; $P = 0.0001$). These differences appeared when the indicator value (IV) of the species was analysed (Tables 2 and 3). The taxa *Lepidostoma hirtum*, *Silonella aurata*, *Allogamus gibraltarius*, *Hydropsyche infernalis* and *Diplectrona felix* were characteristic of streams of group 1; *Rhyacophila fonticola* inhabited both streams for group 1 and 2; whereas *Polycentropus kingi* and *Tinodes* sp. were the indicative species of gorges of group 2; *Chimarra marginata* and *Hydropsyche iberomaroccana* were associated with the sections of groups 2 and 3; lastly *Rhyacophila munda*, *H. lobata* and *L. lusitanicus* preferred the main channel of the river and broader riverbeds (group 3).

Table 2. Indicator value (IV) of the species for the three respective groups of pooled samples identified by discriminant analysis.

Code	Species	Group 1	Group 2	Group 3
Cama	<i>Calamoceras marsupus</i> BRAUER, 1865	2	30	0
Sfe	<i>Schizopelex festiva</i> (RAMBUR, 1842)	10	49	2
Esc	<i>Erotasis schaschti</i> MALICKY, 1982	0	33	0
Llu	<i>Leptocerus lusitanicus</i> (McLACHLAN, 1884)	0	0	44
Maz	<i>Mystacides azurea</i> (LINNAEUS, 1761)	0	26	48
Sar	<i>Setodes argentiunctellus</i> McLACHLAN, 1877	0	0	33
Lhi	<i>Lepidostoma hirtum</i> (FABRICIUS, 1775)	75	0	0
Sau	<i>Silonella aurata</i> (HAGEN, 1864)	65	2	0
Amo	<i>Allogamus mortoni</i> (NAVÁS, 1907)	50	0	0
Agi	<i>Allogamus gibraltarius</i> GONZÁLEZ and RUIZ, 2001	75	0	0
Ede	<i>Ecnomus deceptor</i> McLACHLAN, 1884	0	5	16
Tin	<i>Tinodes</i> sp.	0	50	0
Pki	<i>Polycentropus kingi</i> McLACHLAN, 1881	3	77	6
Hlo	<i>Hydropsyche lobata</i> McLACHLAN, 1884	0	3	61
Hib	<i>Hydropsyche iberomaroccana</i> GONZÁLEZ and MALICKY, 1999	0	29	58
Hsi	<i>Hydropsyche siltalai</i> DÖHLER, 1963	1	57	4
Hin	<i>Hydropsyche infernalis</i> SCHMID, 1952	75	0	0
Dfe	<i>Diplectrona felix</i> McLACHLAN, 1878	75	0	0
Cma	<i>Chimarra marginata</i> (LINNAEUS, 1767)	0	6	72
Oun	<i>Oxyethira unidentata</i> McLACHLAN, 1884	0	11	8
Ase	<i>Agraylea sexmaculata</i> CURTIS, 1834	0	18	42
Ith	<i>Ithytrichia</i> sp.	0	0	33
Hyd	<i>Hydroptila</i> sp.	0	7	44
Ain	<i>Agapetus incertulus</i> McLACHLAN, 1884	35	10	0
Rmu	<i>Rhyacophila munda</i> McLACHLAN, 1862	1	1	82
Rfo	<i>Rhyacophila fonticola</i> GIUDICELLI and DAKKI, 1984	44	45	0

Table 3. Monte Carlo test of significance of observed indicator value (IV) for species in each group of samples identified by discriminant analysis.

GROUP 1

Species	IV	P
<i>Rhyacophila fonticola</i>	96.4	0.004
<i>Lepidostoma hirtum</i>	75	0.008
<i>Silonella aurata</i>	75	0.008
<i>Allogamus gibraltarius</i>	75	0.008
<i>Hydropsyche infernalis</i>	75	0.008
<i>Diplectroa felix</i>	75	0.008

GROUP 2

Species	IV	P
<i>Polycentropus kingi</i>	86.9	0.037
<i>Chimarra marginata</i>	83.3	0.041
<i>Hydropsyche iberomaroccana</i>	83.3	0.05
<i>Rhyacophila fonticola</i>	80.9	0.006
<i>Tinodes</i> sp.	50	0.047

GROUP 3

Species	IV	P
<i>Hydropsyche iberomaroccana</i>	88.9	0.023
<i>Rhyacophila munda</i>	85.8	0.022
<i>Chimarra marginata</i>	77.8	0.047
<i>Hydropsyche lobata</i>	62.9	0.021
<i>Leptocerus lusitanicus</i>	44.4	0.030

3.3. Seasonal Variations in the Communities

Table 4 shows the significant changes of diversity, richness and abundance according to the water residence of the section studied and the seasonal variations. Riverbeds were grouped in three categories: permanent (with water the whole year); intermittent (with isolated pools in dry periods) and ephemeral (completely dry just in summer). Differences among the three types of sites were not significant. However, the changes in richness and diversity in the permanent sites were significant, higher in spring-summer than autumn-winter.

The MRPP analysis pointed out the changes in the communities of caddisfly between the permanent, intermittent and ephemeral sites and through the year (Table 5). We distinguished the autumn-winter communities from the summer ones. Table 6 shows the species significantly associated with section of the system with permanent or intermittent flow. Trichoptera species associated with ephemeral sites were not detected in the analysis.

A second CCA with physico-chemical environmental variables and biological seasonal data was performed. Three significant axes were extracted and significant Monte-Carlo tests ($P = 0.001$), were obtained for all the axes. Again, the axis 1 represented a geomorphological gradient (salinity – temperature axis). Axis 2 showed a seasonal gradient, and positioned summer samples at the positive end and autumn-winter samples in the negative end of the axis.

Table 4. Changes in abundance, diversity and richness according to the stretch of river and throughout the year, measured using the Kruskal-Wallis test. Significant P-values are in bold.

	DIVERSITY		ABUNDANCE		RICHNESS	
	k-w	P	k-w	P	k-w	P
– stretch type	4.66	0.097	1.75	0.415	2.50	0.285
Seasonality						
– permanent	8.74	0.033	5.93	0.115	8.81	0.032
– intermittent	1.99	0.574	3.55	0.314	3.47	0.324
– ephemeral	0.75	0.685	5.28	0.071	1.08	0.580
– all	0.46	0.141	11.08	0.011	8.01	0.046

Table 5. Significant variations in the structure of the communities of Trichoptera depending on the permanency of the water in the riverbeds and the season. Significant P-values are in bold.

	A	P
Type of running water		
– permanent vs. intermittent	0.205	0.001
– permanent vs. ephemeral	0.125	0.004
– intermittent vs. ephemeral	0.057	0.011
Seasonality		
– winter vs. spring	0.007	0.194
– winter vs. summer	0.035	0.006
– winter vs. autumn	0.002	0.387
– spring vs. summer	0.020	0.082
– spring vs. autumn	0.005	0.259
– summer vs. autumn	0.033	0.023

Table 6. Monte Carlo test of significance of observed maximum indicator value (IV) after discriminant analysis for species in permanent, intermittent and ephemeral stretches.

	PERMANENT		INTERMITTENT		
	IV	P	IV	P	
Lhi	100	0.001	Maz	77	0.018
Agi	100	0.001	Cma	73.2	0.008
Dfe	100	0.001	Hib	71.1	0.011
Sau	96.9	0.001	Rmu	67.2	0.035
Hin	92	0.001			
Ain	57.7	0.020			

In Figure 4 we can distinguish different groups of species whose pattern of distribution changed throughout the year: species whose populations are maintained throughout the year (e.g. *Diplectrona felix*, *Erotesis schachtii*, *Polycentropus kingi*, *Hydropsyche iberomaroccana* and *Chimarra marginata*); autumn-winter species (e.g. *Hydropsyche infernalis*, *Rhyacophila fonticola*, *Schizopelex festiva*, *Hydropsyche siltalai*, *Rhyacophila munda* and *Hydropsyche lobata*) and two groups of summer species: *Allogamus mortoni*, *A. gibraltarius*, *Silonel-*

Figure 4. Projection of the two first axis of the CCA with seasonal data. Symbol code categories of the variable Annual (1. winter (w); 2. spring (sp); 3. summer (s) and 4. autumn (a)) is showed at the end of the acronyms of the sites. + symbol show species. Species codes are explained in Table 2.

la aurata and *Lepidostoma hirtum* in the headstream and *Oxyethira unidentata*, *Ithytrichia* sp. *Mystacides azurea*, *Setodes argentipunctellus* and *Leptocerus lusitanicus* present in isolated pools that keep water during the whole dry period.

3.4. Biogeographical Characteristics

The 29 species considered in this study belong to seven biogeographical categories (Fig. 5). The species of North African distribution were dominant (37.8%), followed by the European and Mediterranean ones (24.1% and 17.2%, respectively). The Iberian endemisms constituted 13.7% of the total record.

Figure 5. Comparison of the Trichoptera associations in headstreams ("Canutos") (RUIZ *et al.*, 2001) and the high basin of the Hozgarganta River. The biogeographical categories are based on GONZÁLEZ *et al.* (1992).

4. Discussion

The existence of a longitudinal gradient is characteristic for all rivers. This gradient determines the physico-chemical conditions and the invertebrates they inhabit (PRENDA and GALLARDO-MAYENCO, 1999).

The irregularity in the flow is one of the most important features of the Mediterranean rivers (VIDAL-ABARCA *et al.*, 1992; SABATER *et al.*, 1993; GIUDICELLI *et al.*, 1985), and in some periods they can be dry (FERRERAS-ROMERO and GARCÍA ROJAS, 1995; COIMBRA *et al.*, 1996). Some authors have found that water chemistry as well as community structure are strongly affected by discharges (SABATER *et al.*, 1991; PUIG *et al.*, 1990).

In several Spain basins, salinity seems to be an important factor explaining the aquatic organism distribution (GALLARDO-MAYENCO, 1991; 1994; RUIZ, 2000). In addition, as consequence of human activities several waterbasins are contaminated (PRAT *et al.*, 1997; PRENDA and GALLARDO-MAYENCO, 1996; BONADA *et al.*, 2000). Our study suggest that the water quality of Hozgarganta River basin located inside the Los Alcornocales Natural Park is good, because there are no indications of alteration that could not be explained by natural causes.

Nevertheless, in spite of the good relationship between the physico-chemical characteristics of the environment and the distribution of aquatic organisms (GILLER and MALMQVIST, 1998) the explanatory power of these variables may be poor, especially in the case of Trichoptera (CORTES *et al.*, 1998; AGUIAR *et al.*, 2002; VIVAS *et al.*, 2002; BONADA, 2003). In this study, only 34.6% of the variance is explained by the three selected axes. The high disturbance to which the Mediterranean rivers are exposed, their intermittence and seasonality could explain this low predictability (AGUIAR *et al.*, 2002; VIVAS *et al.*, 2002; KAY *et al.*, 2001). In the study no alteration of human origin has been found, nevertheless, water permanence is very important, because just 16% of the studied stretches had permanent flow. The water residence and the geomorphological gradient (salinity-thermal axis) could both be the principal environmental factors characterising the river high basin, similar to other nearby areas previously studied (GALLARDO-MAYENCO, 1991; RUIZ, 2000). These results are in agreement with those obtained by BONADA (2003) and BONADA *et al.* (2005) in a ten Mediterranean basins study, where the geomorphology and the physico-chemical parameters were the best explanatory factors predicting caddisfly community's distribution. However, our results also showed differences in the structure of the autumn-winter and summer assemblages. We also were able to distinguish species associated with permanent sites and intermittent ones (Table 6).

A comparable diversity between intermittent or semi-permanent rivers with permanent ones has been indicated previously in other zones of Spain (PUIG *et al.*, 1991; ALBA-TERCEDOR *et al.*, 1992; RIERADEVALL *et al.*, 1999). Permanent headstreams and pools downstream, which are places of refuge for macroinvertebrates seem to contribute enhancing diversity in the basins of the Mediterranean region (RIERADEVALL *et al.*, 1999; VIDAL-ABARCA *et al.*, 1992). A study in the Mediterranean area of northern California BONADA (2003) has found low convergence in dominant taxa between riffles and isolated pools suggesting that these pools are not refuges of lotic families under a drought. On the other hand, BONADA (2003) in a study of macroinvertebrates in temporary rivers of Catalonia has found similar richness in permanent and intermittent sites, but higher than in the ephemeral ones. In our study we did not find significant differences in richness and diversity between ephemeral and the other sites.

In running water, velocity and temperature seems to be good predictors of the longitudinal distribution (FAESSEL, 1985; ANGELIER, 2000). MARCHANT *et al.* (1995) have suggested that the altitude indirectly affects macroinvertebrates distribution due to the changes in temperature, oxygen contents and discharge. BONADA (2003) has found that altitude, width, stream order and other related variables as conductivity are more significant than the temperature explaining caddisflies distribution. In the study area the geomorphological gradient is the environmental factor that best distinguished among Trichoptera communities, and was related with downstream increase in both mineralisation and water temperature. In our study *H. infernalis*, *R. fonticola*, *S. aurata*, *D. felix*, *A. gibraltarius* and *L. hirtum* were associated with the creeks of high basin, known as «canutos», in agreement with RUIZ *et al.* (2001), which established the same association for the highest streams of the mountains of the Los Alcornocales Natural Park. *L. hirtum* is a poorly known species from the southern Iberian Peninsula (GONZÁLEZ *et al.*, 1992); these populations are the southernmost within their distribution range; in the northern half of Iberian Peninsula it has been situated in mid-stream (DE SOTO *et al.*, 1994), in waters of siliceous nature (SOTO *et al.*, 1990), the same habitat that it occupies in the basin of the Hozgarganta River. GARCÍA DE JALÓN and GONZÁLEZ DEL TÁNAGO (1986) found *S. aurata* in the rhithron of rivers of the province of Málaga and it has been recorded in headstreams of Cadiz (RUIZ, 2000), and our results support this pattern. On the other hand, *D. felix* is inhabitant of the crenon and rhithron (MORETTI, 1983) and, in Galicia, the species lives in mountainous regions (GONZÁLEZ, 1988). In spite of being distributed in the North of Africa, these are the only populations known from the South of the Iberian Peninsula (GONZÁLEZ *et al.*, 1992); it is one of the most frequent and abundant species in the «canutos» (RUIZ *et al.*, 2001). Regarding the others, *H. infernalis*, *A. gibraltarius* and *A. mortoni* are Iberian endemisms, and *R. fonticola* is a species frequently found in the canutos and gorges of the mountains of the Los Alcornocales Park (RUIZ *et al.*, 2001).

C. marginata, *H. iberomaroccana*, *R. munda*, *H. lobata* and *Leptocerus lusitanicus*, were found principally in the main channel of the river, with warmer and more mineralised waters, although both *C. marginata* and *H. iberomaroccana* were also associated with *Polycentropus kingi* and *Tinodes* sp. (group 2). In a study of several rivers of the province of Cadiz, RUIZ (2000) found *C. marginata* and *H. iberomaroccana* (then called *H. cf punica*) in high basins, as in our observations. On the other hand, GONZÁLEZ DEL TÁNAGO and GARCÍA DE JALÓN (1987) have proposed *H. iberomaroccana* and *R. munda* as indicator species of potamon. Probably, *R. munda* is able to live in a wide range of ecological conditions, inhabiting in many headwaters as well as warm temporary streams and lowland rivers (GARCÍA DE JALÓN and GONZÁLEZ DEL TÁNAGO, 1986). In the basin of the Hozgarganta this species is displaced from the headstream to the main channel of the river by *R. fonticola*. In the case of *P. kingi*, it is a widespread species, being able to live in both permanent (GALLARDO-MAYENCO, 1991; RUIZ, 2000) and temporary reaches (GONZÁLEZ DEL TÁNAGO and GARCÍA DE JALÓN, 1987).

M. azurea is a ubiquitous species that lives in middle and low reaches and pools (GARCÍA DE JALÓN and GONZÁLEZ DEL TÁNAGO, 1986), rhithron with vegetation (SOTO *et al.*, 1990) and in lentic and eutrophic environments (BASAGUREN and ORIVE, 1991). RUIZ (2000) has mentioned *S. festiva* in siliceous headwaters but this new record suggests that this species has a wide ecological tolerance range.

The biogeographical analysis showed that most of our species were North African distribution elements (Fig. 5). We observed a slight decrease in the North African and Iberian endemic species when comparing the fauna of the Hozgarganta basin from that living in headwaters of the protected area (RUIZ *et al.*, 2001). On the contrary, there was a greater proportion of European, Mediterranean and Palearctic species. In short, the community of caddisfly that lives in headwaters is replaced by a common fauna in the lower sections.

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