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The Trichoptera fauna of the Oja River (La Rioja, Spain)

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Abstract

The Oja River (La Rioja, Spain), belonging to the Ebro River Basin (NE Spain), encloses 3 different fluvial types (*Mediterranean siliceous mountain*, *Mediterranean calcareous mountain* and *Humid calcareous mountain* rivers) that give rise to a great diversity in the fauna of aquatic macroinvertebrates.

During the years 2003−2009 benthic macroinvertebrates (aquatic stages and adults) were sampled in 7 sites along the river (3 in siliceous stretches, 1 in humid calcareous stretch and 3 in calcareous stretches) in different seasons.

We have found 54 Trichoptera taxa, belonging to 31 genera and 16 families. Hydropsychidae (10 species), Limnephilidae (7 species) and Rhyacophilidae (7 species) were the dominant families. Most of the species have wide European distribution (50%), with the Iberian endemic species (22%) and Central and Western European species (18%) being the 2nd and 3rd groups in importance.

The presence of some relict species in headwaters [*Thremma gallicum* McLachlan, *Larcasia partita* Navas and *Odontocerum albicorne* (Scopoli)] support the inclusion of this geographical area (Sierra de la Demanda, Iberian System Mountains) in the list of European pre-Pleistocene refuges for the Trichoptera fauna.

Key words: benthic macroinvertebrates, caddisfly, endemic species, relict species

Introduction

The aquatic entomofauna of La Rioja (Spain) was studied for the first time in the early 20th century by Navás (1914; 1917a, b), mainly in the mountainous areas of Ortigosa, Valvanera and Sierra de Cameros (Iregua and Najerilla Rivers). García de Jalon (1982a, b, c) in his papers about Spanish Trichoptera provides information about Trichoptera from Iregua and Nájera Rivers. On the other hand, there is scarce information of the aquatic fauna of Oja River: one paper about Coleoptera of the Iberian System that includes Oja River (Valladares *et al*. 2000), and 3 recent papers with preliminary results on aquatic macroinvertebrates (Martínez-Bastida *et al*. 2006; Valladolid *et al.* 2006, 2007).

Knowledge of Spanish Trichoptera has increased in recent years, not only with the description of larvae or new species (Vieira-Lanero 2000) and with the preparation of specific keys (Zamora-Muñoz *et al*. 1992, 1995; Vieira-Lanero 2000; Ruiz *et al*. 2004) but also with the publication of faunistic data (González *et al*. 1992, Ruiz *et al*. 2001, González 2003, Bonada *et al*. 2004). We want

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to improve this knowledge with information about the caddisfly fauna from Oja River, an almost unknown river of La Rioja that gives its name to the Community.

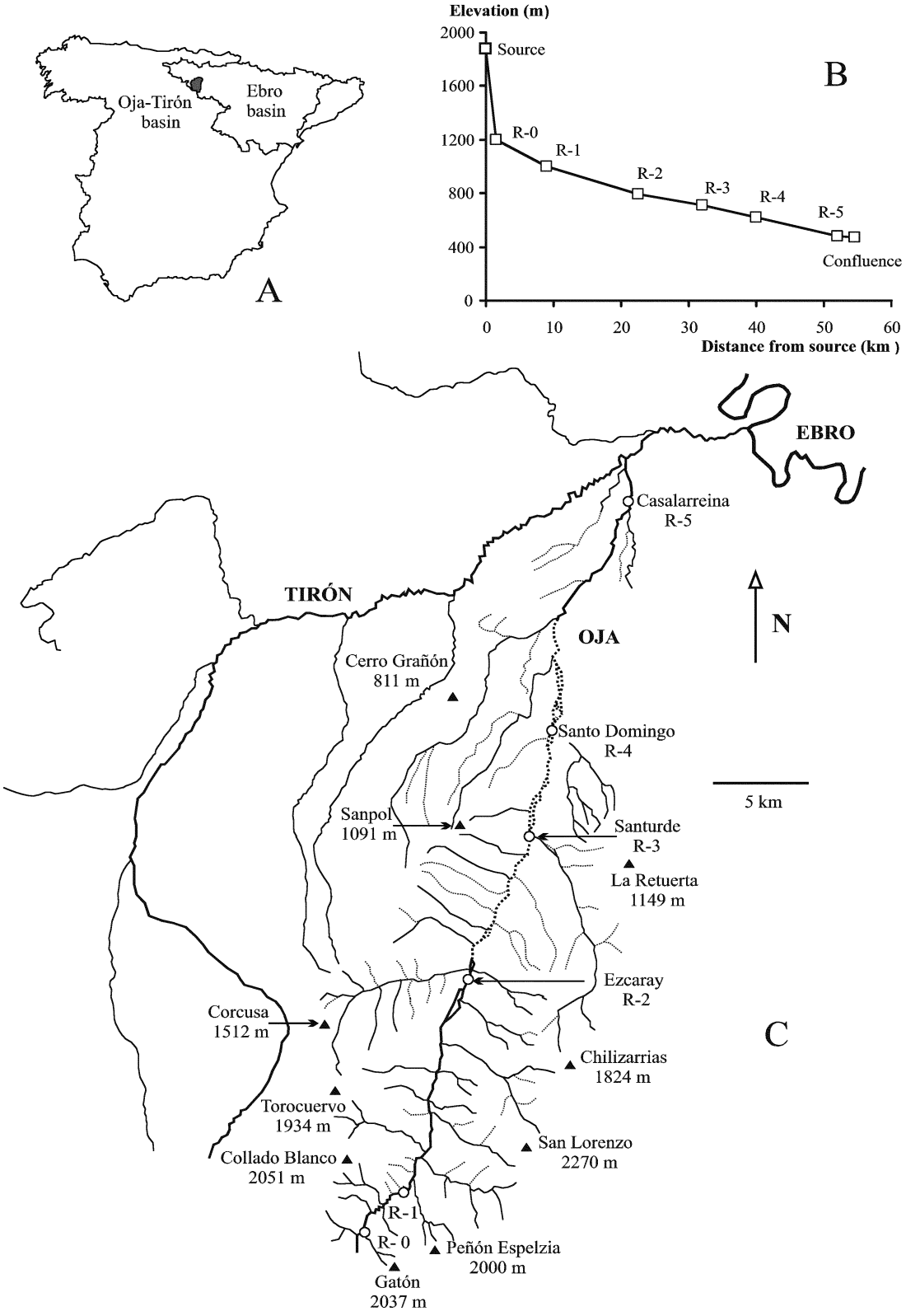

FIGURE 1. Location of Oja River. A) Situation of the Oja-Tirón basin into the Ebro basin. B) Longitudinal profile of Oja River. C) Map of the Oja-Tirón basin, with sampling points. R-0: Eagle's dam (Oja River and tributary), R-1: Oja river upstream Posadas.

Study area

The study was carried out along the Oja River (La Rioja, Spain) (Fig.1). Originating by the union of several creeks (from 1800 to 1500 m a.s.l.) fed with snowmelt, the river is in the Sierra de la Demanda (Iberian System Mountains) and goes through 54.5 km in a northerly direction before reaching the Tirón River, a right tributary of Ebro River (NE Spain). It is entirely located in the High Rioja district and, except for the headwaters, the river flows through a wide alluvial plain that is devoted mainly to intensive agriculture (crop rotation in humid Mediterranean climate). The river is characterized by extreme flow fluctuations during the year, with middle and low stretches dry during several months, due mainly to the high porosity of the aquifer and its exploitation for agriculture. On the other hand, the lowest stretch of the river works as the drainage area of the underlying alluvial aquifer, keeping running water even in the most severe periods of drought. According to the European Water Framework Directive, the Confederación Hidrográfica del Ebro (CHE: River Ebro Water Authority) divides the Oja River in 3 different fluvial types: a) siliceous Mediterranean mountain river, in the headwaters, with a Paleozoic origin; b) humid calcareous mountain river, around Ezcaray, over Mesozoic units and c) calcareous Mediterranean mountain river, downstream of Ezcaray, in Cenozoic areas (Tertiary and Quaternary materials) that enclose the alluvial aquifer. In type a) we sampled points R-0, R-0-T and R-1 (1200-1000 m a.s.l.), in type b) we sampled point R-2 (Ezcaray, 790 m a.s.l.) and in type c) we sampled points R-3 to R-5 (711 to 480 m a.s.l.). The geographical information is summarized in Table 1.

TABLE 1. Sampling sites. *Point*: reference number, *Location*: nearest locality. * Sampling points added in 2005. UTM coordinates have been calculated from the Map Number 21-11 (240), Ezcaray (Spanish Military Cartography, Scale 1: 50.000, L Series, 1989).

Point	Location	UTM coordinates	Altitude (m)
R-0-T	Eagle's dam, tributary	30T 493900 4673000*	1200 m*
R-0	Eagle's dam, Oja River	30T 493900 4673000*	1200 m*
R-1	Posadas	30T 494300 4687373	1000 m
R-2	Ezcaray	30T 499341 4687339	790 m
R-3	Santurde	30T 503289 4699294	711 m
R-4	Santo Domingo de la Calzada	30T 503323 4699202	616 m
R-5	Casalarreina	30T 507069 4708340	480 m

Material and methods

During 2003–2004, a variable number (6–12) of seasonal, quantitative samples of macroinvertebrates were taken in 5 selected sites (from R-1 to R-5) in May, August, November 2003 and February 2004. In 2005, upstream of R-1, two sites were included: R-0 in Oja River and R-0-T in a tributary of Oja River [see Table 1 and Valladolid *et al*. (2007) for additional information]. Additional qualitative samples were taken in 2004 (R-1 in June, R-5 in November), 2005 (R-5 in March; R-0 and R-0-T in May; R-1 in June; R-0, R-0-T and R-1 in August), 2006 (R-1 and R-5 in June), 2007 (R-1 and R-5 in June), 2008 (R-1, R-2, R-4 and R-5 in May and June; R-1, R-2 and R-5 in August and September) and 2009 (R-1, R-2 and R-5 in June, July, August and September) .

Invertebrates were collected with a standard Surber sampler of 30 x 30 cm and 250 μm mesh net and drift samples were collected during 30 min. with a drift net of 30 x 30 cm square mouth and 250 μm mesh net. Samples were fixed in the field with formalin 10% buffered with 0.9% NaCl. Adults

were collected with light trap and sweepnet in R-1 and R-5 (2008) and in R-1, R-2 and R-5 (2009). Samples were fixed in the field with 70% ethanol.

In the laboratory the different taxa were sorted under a dissecting microscope and preserved in 70% ethanol. The identification of caddisflies was made using available literature: general books (Tachet 2003) and specific keys and descriptions of larvae and adults (Zamora-Muñoz *et al*. 1995, Waringer & Graf 1997, Vieira-Lanero 2000, Malicky 2004, Neu & Tobias 2006). Spanish and European experts checked doubtful determinations of certain larvae. The Iberian distribution of species is based on the works of González *et al*. (1992) and Vieira-Lanero (2000) and the correct nomenclature and European distribution were checked in the web pages of Fauna Europaea (Barnard & Malicky 2004) and of Trichoptera World Checklist (Morse 2006).

Results

1. Trichoptera species

A total of 7151 individuals (4853 larvae, 267 males, 503 females and 1528 pupae of different levels of maturity) were collected (Table 2). We have identified 54 taxa (28 with larvae & adult stages, 21 with larvae stages and 5 with adult stages), belonging to 16 families (76% of those present in the Iberian Peninsula. The best represented families are Hydropsychidae with 10 species [*Hydropsyche ambigua* Schmid, *H. angustipennis* (Curtis), *H. bulbifera* McLachlan, *H. dinarica* Marinkovic-Gospodnetic, *H. exocellata* Dufour, *H. incognita* Pitsch, *H.* gr. *instabilis* (Curtis), *H. lobata* McLachlan, *H. pellucidula* (Curtis) and *H. siltalai* Doehler]; Limnephilidae with 7 species [*Allogamus laureatus* (Navas), *A. ligonifer* (McLachlan), *Chaetopteryx* sp., *Halesus digitatus* (Paula Schrank), *H. radiatus* (Curtis), *Limnephilus guadarramicus* Schmid and *Potamophylax latipennis* (Curtis)] and Rhyacophilidae with 7 species [*Rhyacophila fasciata* cf. *denticulata* McLachlan, *R. intermedia* McLachlan, *R. meridionalis* E. Pictet, *R. obliterata* McLachlan, *R. occidentalis* McLachlan, *R. terpsichore* Malicky and *R. tristis* F.J. Pictet].

TABLE 2. List of caddis species collected. *Cites*: n.c.: new cite for La Rioja, 1: García de Jalón (1982 b), 2: García de Jalón (1982 c), 3: García de Jalón (unpublished), 4: Navás (1908), 5: Navás (1914), 6: Navás (1916), 7: Navás (1918), 8: Navás (1920), 9: Navás (1922), 10: Schmid (1949), 11: Valladolid et al. (2006), 12: Valladolid et al. (2007). *ED*: European distribution. EU: Europe, WE: West Europe, CWE: Central and Western Europe, EWE: Eastern and Western Europe, PAL: Palaearctic, IP: Iberian Peninsula. *ID*: Iberian distribution. N: North basins, NC: North and Central basins, NE: Northeastern basins, NWC: Northwest and Central basins A: widespread. *Specimens*. L: larvae, P: mature & immature pupae ([1]: immature pupae, [2]: male & female pupae), M: adult males, F: adult females. *Flight*: months with adults. [3]: possible *Wormaldia corvina.*

Species	Cites	ED	ID	Specimens	Flight
Rhyacophila fasciata cf. denticulata Mc Lachlan, 1879	n.c.	IP	NE	8L+17P+***7M+7F***	VI-IX
Rhyacophila meridionalis E. Pictet, 1865	1	WE	A	35L+46P+***6M+5F***	VI-IX
Rhyacophila obliterata McLachlan, 1863	1,11	EU	NC	27L+2P	
Rhyacophila occidentalis McLachlan, 1879	1,4,8	WE	A	40L+46P+***8M+4F***	VII-IX
Rhyacophila intermedia McLachlan, 1868	n.c.	CWE	A	4L	
Rhyacophila terpsichore Malicky, 1976 (“1975”)	3	IP	NC	3L+2P	
Rhyacophila tristis F.J. Pictet, 1834	3	EU	NC	8L	
Glossosoma privatum McLachlan, 1884	9,10	IP	A	115L+95P+***5M***	VII-IX
Agapetus delicatulus McLachlan, 1884	n.c.	CWE	A	***3M+25F***	VII
Synagapetus sp.	n.c			2L	
Oxyethira sp.	n.c.			***4F***	VII-VIII

Species	Cites	ED	ID	Specimens	Flight
Hydroptila sp.				637L+51P[1]	
Hydroptila vectis Curtis, 1834	n.c.	EU	A	61P[2]+***15M+61F***	VI-IX
Hydroptila sparsa Curtis, 1834	n.c.	EU	NC	***1M+2F***	IX
Hydroptila gr. sparsa	n.c			***4F***	VII-IX
Agraylea sexmaculata Curtis, 1834	n.c.	EU	A	***1M***	IX
Philopotamus montanus (Donovan, 1813)	3,5,9	EU	A	7L+3P+***38M+6F***	VI-IX
Wormaldia corvina (McLachlan, 1884)	n.c.	IP	NWC	7L+1P+***14M***	VI-VIII
Wormaldia sp.[3]				***1F***	VII
Hydropsyche ambigua (Schmid in Schmid & Botosaneanu, 1973)	12	IP	NC	100L+63 P+***21M+55F***	VII-IX
Hydropsyche gr. instabilis	12			72L+27P+***1M***	VI
Hydropsyche siltalai Doehler, 1963	1,11,12	EU	A	390L+64P+***14M+65F***	VI-IX
Hydropsyche angustipennis (Curtis, 1834)	12	EU		42L	
Hydropsyche bulbifera McLachlan, 1878	12	EU	A	69L	
Hydropsyche exocellata Dufour, 1841	12	CWE	A	585L+31P+***39M+107F***	VI-IX
Hydropsyche dinarica Marinkovic-Gospodnetic, 1979	12	EU	A	29L+22P+***1M+4F***	VII-IX
Hydropsyche incognita Pitsch, 1993	12	EU	A	177L+13P+***11M+67F***	VI-IX
Hydropsyche lobata McLachlan, 1884	11,12	IP	A	9L	
Hydropsyche pellucidula (Curtis, 1834)	1,4	EU	A	24L+3P+***2M+10F***	VI-IX
Plectrocnemia conspersa (Curtis, 1834)	n.c.	EU	NC	25L+***5M+1F***	VI-IX
Polycentropus flavomaculatus (Pictet, 1834)	2	EU	A	610L+34P+***6M+13F***	VI-IX
Polycentropus kingi McLachlan, 1881	2	CWE	A	12L+26P+***12M+5F***	VII-IX
Lype sp.	n.c			2L	
Psychomyia ctenophora McLachlan, 1884	n.c.	IP	NC	6L+***1M*** +***1F***	VIII-IX
Psychomyia pusilla (Fabricius, 1781)	2,11	EU	A	3L+1P+***3F***	VI-VII
Tinodes assimilis McLachlan, 1885	9	CWE	A	2L+***1M***	VI
Micrasema longulum McLachlan, 1876	3,11	CWE	A	5L+35P	
Micrasema minimum McLachlan, 1876	11	EU	NC	102L+500P	
Micrasema moestum (Hagen, 1868)	n.c	WE	A	2L	
Lepidostoma hirtum (Fabricius, 1775)	2,5,8	EU	A	10L+1P+***1M+1F***	VI-VII
Limnephilus guadarramicus Schmid, 1955	n.c.	IP	NWC	4L	
Potamophylax latipennis (Curtis, 1834)	2	EU	A	53L+94P+***36M+12F***	VIII-IX
Halesus digitatus (Paula Schrank, 1781)	n.c.	EU	NE	7L	
Halesus radiatus (Curtis, 1834)	n.c.	EU	NC	2L	
Allogamus laureatus (Navas, 1918)	n.c.	IP	NC	8L	
Allogamus ligonifer (McLachlan, 1876)	2	CWE	A	50L+***3M+4F***	IX
Chaetopteryx sp.				27L	
Thremma gallicum McLachlan, 1880	n.c.	CWE	NC	17L+23P	
Larcasia partita Navas, 1917	2	IP	NC	1042L+135P+***5M+20F***	VI-VIII
Silo graellsii E. Pictet, 1865	5,6,7,8,10	EWE	NC	2L+2P	
Adicella reducta (McLachlan, 1865)	9	EU	A	3L+***1M***	VII
Ceraclea dissimilis (Stephens, 1836)	n.c.	EU	NC	1L+***2M+6F***	VI
Mystacides azureus (Linnaeus, 1761)	n.c.	PAL	A	6L	
Sericostoma personatum (Spence in Kirby & Spence, 1826)	n.c.	EU	NE	322L+126P+***4M+8F***	VII-VIII
Beraea terrai Malicky, 1975	n.c.	IP	NWC	79L+2P	
Odontocerum albicorne (Scopoli, 1763)	2,4,5,8,9	EU	NC	7L+4P+***2M+1F***	VII-VIII

Table 2 summarizes the information about Trichoptera species collected in Oja River: European distribution, Iberian distribution, number of specimens and date of capture of adults. Adults were sampled from April-May to September and first captures were in June in both years.

2. Longitudinal distribution of taxa and river zonation

We found the highest number of species in siliceous stretch (headwaters), with 25 and 31 species in R-0 and R-1, respectively, followed by humid calcareous stretch (R-2, 26 sp.) and calcareous stretch (24 sp. in R-5). In points R-3 and R-4 (calcareous stretch) we found only 2 and 4 species, respectively (Polycentropodidae and Hydropsychidae). The low diversity at these latter sites is probably related to the characteristics of the river at these points: a wide channel, with several arms and shallow waters that give rise to small pools in late spring and dry soon afterward, together with very little vegetation in the river bed and in the margins.

The longitudinal distribution of taxa (aquatic stages only) is shown in Table 3. We found 16 taxa located only in one of the sampling sites: *Rhyacophila intermedia* and *R. terpsichore* in R-0 (1200 m), *Allogamus laureatus* and *Beraea terrai* Malicky in R-1 (1000 m), *Synagapetus* sp. and *Limnephilus guadarramicus* in R-2 and *Rhyacophila fasciata* cf. *denticulata*, *Hydropsyche angustipennis*, *H. incognita*, *H. pellucidula*, *Lype* sp., *Psychomyia pusilla* (Fabricius), *Tinodes assimilis* McLachlan, *Micrasema moestum* (Hagen), *Ceraclea dissimilis* (Stephens) and *Mystacides azureus* (L.) in R-5. Eleven taxa were found in 2 sampling sites, 18 on at least 3 and probably only 1 (*Hydroptila vectis* Curtis*)* inhabits the length of the river.

Table 3 shows different faunas related with the river stretches: upper (R-0, R-1), middle (R-2) and lower (R-5). The most different fauna lives in the lowest stretch, with the upper-middle stretches (R-0, R-1 and R-2) more related through their faunas. The highest number of taxa on site R-1 probably reflects a transition between faunas from R-0 and R-2.

3. Biogeographical notes

Figure 2 shows the contribution of different biogeographical groups in the caddis fauna of Oja River. Most of the species (50%) have a European distribution, with the endemic species the 2nd group in importance (22%) and those with a Central and West European distribution the next group in importance (18%). One important feature of the Trichoptera fauna of Oja River is the presence of species considered relicts, such as *Larcasia partita* Navas, *Odontocerum albicorne* (Scopoli) and *Thremma gallicum* McLachlan, with a pre-Pleistocene origin (Giudicelli 1971, Malicky 1983, González *et al*. 1987).

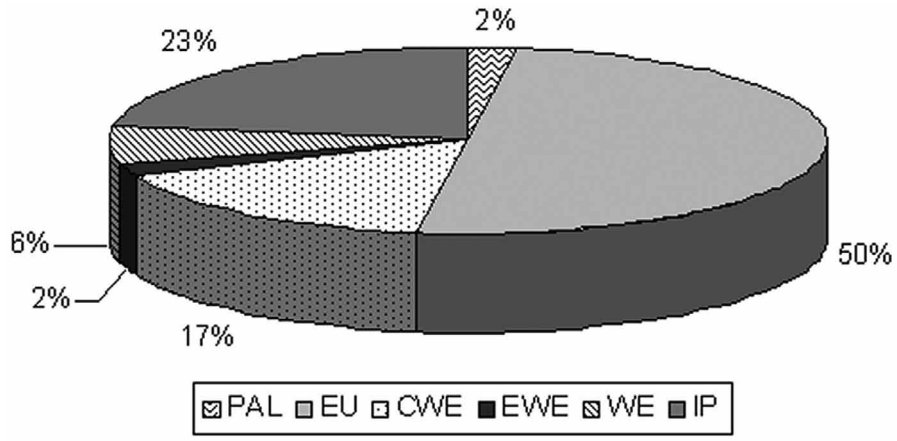

FIGURE 2. Biogeographical composition (in %) of the Trichoptera fauna from Oja River. Number of scpecies included: 48. Biogeographical category: *PAL*: Palaearctic, *EU*: Europe, *CEW*: Central and Western Europe, *EWE*: Eastern and Western Europe, *WE*: Western Europe, *IP*: Iberian Peninsula.

TABLE 3. Altitudinal distribution of aquatic stages of Trichoptera collected. * Probably *Hydroptila vectis* is the dominant taxon; other species found (adults) in R-5 were *H. sparsa* and *H. gr. sparsa*. *In grey*: stretches with intermittent flow. *SMR*: Siliceous Mediterranean mountain river type, *HCMR*: Humid calcareous mountain river type, *CMR*: Calcareous Mediterranean mountain river type.

	SMR		HCMR	CMR		
Species	R-0 1200 m	R-1 1000 m	R-2 790 m	R-3 711 m	R-4 616 m	R-5 480 m
Rhyacophila intermedia	1					
Rhyacophila terpsichore	1					
Micrasema minimum	1	1				
Odontocerum albicorne	1	1				
Philopotamus montanus	1	1				
Rhyacophila occidentalis	1	1				
Rhyacophila tristis	1	1				
Silo graellsii	1	1				
Thremma gallicum	1	1				
Wormaldia corvina	1	1				
Allogamus laureatus		1				
Beraea terrai		1				
Adicella reducta		1	1			
Halesus radiatus		1	1			
Chaetopteryx sp.	1	1	1			
Glossosoma privatum	1	1	1			
Hydropsyche ambigua	1	1	1			
Hydropsyche bulbifera	1	1	1			
Hydropsyche dinarica	1	1	1			
Hydropsyche lobata	1	1	1			
Larcasia partita	1	1	1			
Micrasema longulum	1	1	1			
Polycentropus kingi	1	1	1			
Potamophylax latipennis	1	1	1			
Rhyacophila meridionalis	1	1	1			
Rhyacophila obliterata	1	1	1			
Sericostoma personatum	1	1	1			
Synagapetus sp.			1			
Limnephilus guadarramicus			1			
*Hydroptila sp.**						
Lepidostoma hirtum	1	1	1			1
Allogamus ligonifer		1	1			1
Halesus digitatus		1	1			1
Psychomya ctenophora		1				1
Hydropsyche exocellata			1		1	1
Hydropsyche gr. instabilis			1			1
Hydropsyche siltalai			1	1	1	1
Polycentropus flavomaculatus			1		1	1
Ceraclea dissimilis						1
Hydropsyche angustipennis						1
Hydropsyche incognita						1
Hydropsyche pellucidula						1
Lype sp.						1
Micrasema moestum						1
Mystacides azureus						1
Plectrocnemia conspersa						1
Psychomyia pusilla						1
Rhyacophila fasciata denticulata						1
Tinodes assimilis						1

Figure 3 shows the importance of each biogeographical group in the different sampling points. We can see that the number of species with European distribution increases downstream, while the endemic species decrease. In the headwaters (R-0, R-0-T and R-1), we can see the only species with distribution in Eastern-Western Europe (*Silo graellsii* E. Pictet), while in the lowest point (R-5) we found the only species with a Palaearctic distribution (*Mystacides azureus*).

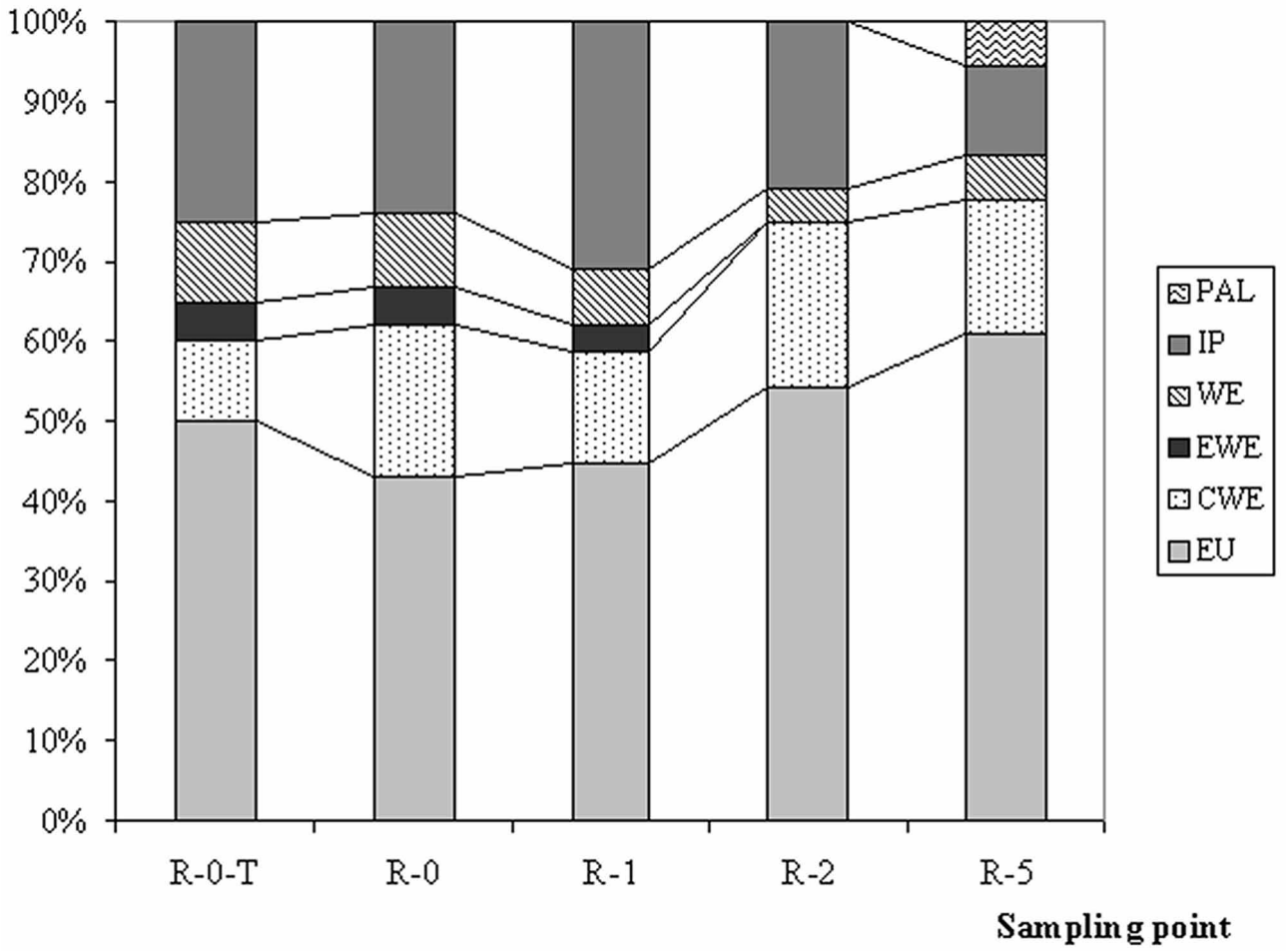

FIGURE 3. Contribution of the different biogeographical groups to the caddis fauna of each sampling point. Biogeographical category: *PAL*: Palaearctic, *EU*: Europe, *CEW*: Central and Western Europe, *EWE*: Eastern and Western Europe, *WE*: Western Europe, *IP*: Iberian Peninsula.

Discussion

The Oja River, despite its short length, holds a rich Trichoptera fauna, both in number of families (16) and in number of species (54). The mixture of environments we found (siliceous, calcareous and humid calcareous reaches), originating in various geological ages, provides the basis for the presence of different Trichoptera faunas. The river is characterized by extreme flow fluctuations during the year, including long periods of time (last spring to early autumn mainly) with middle and low stretches completely dry. This fact prevents the existence of permanent communities of aquatic insects in these areas (R-3 and R-4), reflected in their poor caddis faunas (see Table 3). On the other hand, the areas with permanent water keep stable communities throughout the year, varying their composition according to the seasonal changes (e.g., spring floods).

About the biogeographical distribution of species, Malicky (1983) proposed a new biome type for the caddisflies living in mountain streams, the *dinodal*, whose ecological characteristics are based in the combination of 4 elements: running turbulent water, relatively step slope, hard bottom and high water velocity. In Europe, most of the species of *dinodal* fauna could have originated in the mountainous regions of Central Europe, decreasing in number of species towards the North or the South. The changes in the European territory along the different geological ages could have spread species along defined areas, as for example into southwestern Europe. In this group we can include the species of European distribution, belonging to a group that first spread from the Central Mountains in Europe and also those species with Western distribution, which evolved probably after this first spread, in local areas mainly in France, Spain and Portugal.

A second type of distribution could be placed in a pre-Pleistocene period (Malicky 1983) related with certain Palaeozoic mountains (Hercinic progeny) rejuvenated in a Cenozoic period (Alpine progeny). González *et al.* (1987) formulated the hypothesis that the rivers of the Central System in Spain (e.g., Lozoya River) have acted as a sanctuary for aquatic species, increasing the number of individual endemic species on communities. On the other hand, Giudicelli (1971) in his study of *Thremma* species proposed that this genus is representative of the native European fauna from the Secondary and Tertiary ages. This fact was supported by the systematic isolation of the genus from the rest of the Trichoptera, its location on the old Hercinian Mountains and its distribution along a Circum-mediterranean and Centro European area. Malicky (1983) completed this hypothesis with the addition of *Thremma, Larcasia, Odontocerum* and *Calamoceras*, and genera with one (*Larcasia*) or a few European species that show geographical isolation from closely related genera/species inhabiting tropical areas and that live in geologically "older" mountains and islands (e.g., Central System mountains and Pyrenees in Spain), but not in other areas that are considered "younger" geologically (e.g., Sierra Nevada in Spain). In this group we can find 3 of the 4 representative species: *Larcasia, Odontocerum* and *Thremma.*

There is a 3rd group of species with an African origin, maybe pre-Saharan relicts and with an Atlantic distribution mostly (Malicky 1983), whose distribution is probably related with some of the connections between Europe and North Africa, before the opening of the Strait of Gibraltar in the Pliocene. Ruiz *et al*. (2001), in their paper about the Trichoptera fauna from Los Alcornocales Natural Park (Cádiz, South Spain), found that the most abundant group was the North African species (44.7% of which 38% is present only on the Iberian Peninsula and in Maghreb), followed by endemics of the Iberian Peninsula (20.6 %).

We could conclude that the Trichoptera fauna of the Oja River is the result of different geological and ecological factors. The Sierra de la Demanda (northwest end of the Iberian System Mountains) in its geological history has been connected with Europe and North Africa alternatively. The extent in the distribution of some European species present on the Iberian Peninsula (e.g., Central-Western Europe, Western Europe) could be indicative of the magnitude of their capacity and facilities for spreading.

On the other hand, the isolation of the Iberian Peninsula from Europe, due to the presence in different periods of deep seas (located in the actual Ebro basin and Pyrenees), and its connection with North Africa, was probably the origin of endemic species of the Iberian Peninsula and North Africa, supported by the presence of an increasing gradient N-S of North African – Iberian species (Ruiz *et al*. 2001).

Finally, we could add the Sierra de la Demanda to the list of "old sanctuary mountains" of Europe, due to its geological history as well as to the presence of several relict species such as *Thremma gallicum*, *Larcasia partita* and *Odontocerum albicorne*.

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