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Distribution of Plecoptera in the Duero Basin (Spain)

M. Gonzàlez del Tánago[1]

The distribution of 37 species of Plecoptera in the Spanish area of the Duero basin is studied. A factorial analysis of the data indicates that current and substrate are the major factors controlling the distribution of the stonefly nymphs in the area. Water temperature and periodical drought have also a marked influence on such distributions.

Distribution des Plécoptères dans le bassin du Duero (Espagne).

L'auteur étudie la distribution de 37 espèces de Plécoptères dans la partie espagnole du bassin du Duero. Une analyse factorielle montre que le courant et le substrat sont les principaux facteurs qui contrôlent la distribution des larves de Plécoptères dans cette région. La température de l'eau et l'assèchement périodique ont aussi une nette influence sur cette distribution.

1. — Introduction

The Duero basin is one of the largest in Spain occupying nearly a fifth of the Spanish peninsular surface.

During 1981 and 1982 a general study of the area was carried out (Gonzàlez del Tánago & Garcia de Jalón 1982) in order to establish a biotypological classification of the rivers following Persoone's (1978) proposal for a classification of water courses in the European Communities.

In this paper the results on the plecopteran fauna are discussed, particularly the species distribution in the different zones.

2. — Study area and methods

Seventy six localities distributed on 22 rivers of the Duero basin in Spain were studied. Only 58 supported Plecoptera. Their main physical characteristics have been summarized in Table I and their locations are shown on Fig. 1.

At each locality several physico-chemical parameters of the water were analysed and biological collections were carried out four times in 1981 corresponding to the four seasons. Macroinvertebrates were collected by using hand nets and by removing the substratum, separately on lotic and lentic zones.

3. — Results

Plecoptera from 7 families, represented by 17 genera and 37 species, were collected in the studied area. This represents more than a third of the species cited in the Iberian peninsula (Illies 1978).

It is worthy to mention here the presence in the area of *Brachyptera vera* Berthélemy & Gonzàlez del Tánago and *Taeniopteryx schoenemundi* Mertens (Berthélemy & Gonzàlez del Tánago 1983), *Leuctra occitana* Despax (River Duratón in Laguna de Contreras, 8.III.81 : 1 ♀) and *Capnioneura libera* Navás (River Adaja in Munotello, 15.III.81 : 1 ♂). These species were not cited in Spain before, although some of them were recently found in Portugal (Berthélemy & da Terra 1980).

The northern slope of the basin shelters mainly species which have a large distribution in Europe (Illies 1978) such as *Brachyptera braueri* Klapálek,

1. Dpto Hidrología, E.T.S. de Ingenieros de Montes, Ciudad Universitaria, Madrid - 3, España.

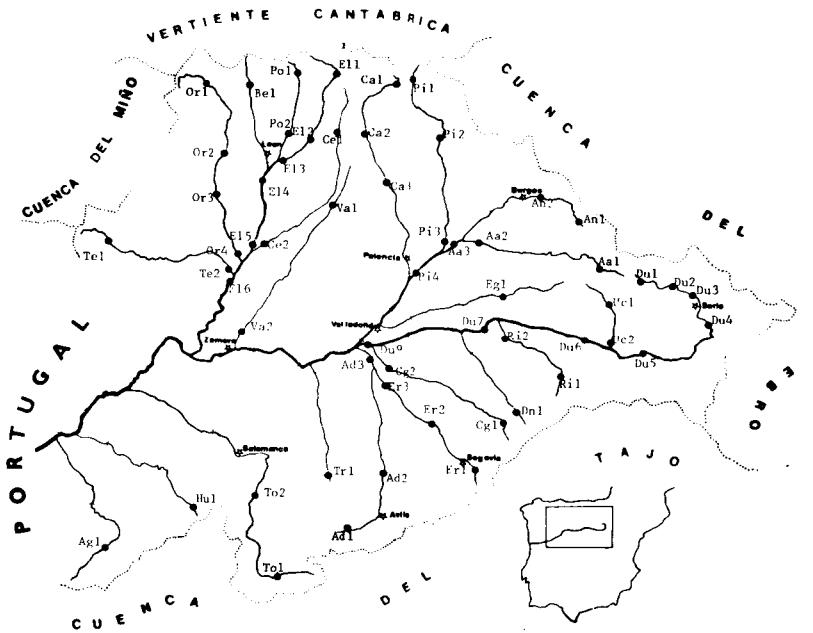

Fig. 1. Study sites in the Duero basin containing Plecoptera.

Taeniopteryx schoenemundi Mertens, *Amphinemura sulcicollis* Stephens, *Protonemura intricata* Ris, *Protonemura meyeri* Pictet, *Euleuctra geniculata* Stephens, *Leuctra fusca* Linné, *Capnia nigra* Pictet, *Perlodes microcephalus* Pictet, *Dinocras cephalotes* Curtis, *Perla bipunctata* Pictet and *Perla marginata* Panzer. These are sometimes also present on the southern slope of the basin, but in smaller numbers.

The most interesting region of the basin from the point of view of Plecoptera is the area of the Sistema Central which includes the Sierra of Guadarrama and Gredos. Some streams have their springs there and they shelter a large diversity of species (see Aubert 1963 ; Berthélemy & Gonzàlez del Tánago 1983 ; Garcia de Jalón & Gonzàlez del Tánago 1982).

A factorial analysis of the data was conducted in order to learn the relationships between species and localities. In this analysis only the semi-quantitative aquatic samples were considered. The results for the four sampling periods were summarized and the relative abundance of each species was determined by establishing 8 classes along a geometric series of rate 2, in order to eliminate the influence of large numbers (Table II).

Factorial analysis was first used on river ecosystems by Verneaux (1973) and subsequently by others (Giudicelli 1980 ; Gonzàlez del Tanágo & al. 1981). It allows an elucidation of the biological structure of the river communities.

Table I. Principal physical characteristics of the sampling stations.

River	Station	Km to source	Altitude m	Slope %	Width m	Substratum	Mean Summer Temperature	Observations
R. Duero	Du1	8	1 200	25	7	Stones	17.0	
	Du2	45	1 080	3.2	25	Gravel	16.5	Below a dam
	Du3	78	1 010	2.1	25	Gravel	18.5	
	Du4	115	980	0.8	17	Sand	19.5	
	Du5	200	900	0.9	31	Gravel	19.5	
	Du6	285	860	0.5	30	Gravel	19.5	
	Du7	384	750	0.9	53	Gravel	22.0	
	Du9	503	690	0.6	36	Gravel	22.5	
R. Ucero	Uc1	34	980	10	11	Stones	12.0	
	Uc2	78	890	2	10	Stones	19.5	
R. Pisuerga	Pi1	10	1 080	15	15	Stones	17.0	
	Pi2	113	870	1.1	30	Gravel	16.0	Below a dam
	Pi3	216	770	1	30	Gravel	21.5	
	Pi4	244	740	1.1	46	Gravel	22.0	
R. Arlanza	Aa1	8	1 090	5	9	Stones	22.0	
	Aa2	160	790	2	30	Stones	21.0	
	Aa3	180	770	1	43	Gravel	21.5	Relatively polluted
R. Arlanzón	An1	10	1 200	14	6	Stones	15.5	
	An2	48	920	7.4	12	Stones	18.0	
R. Esgueva	Eg1	70	880	6	7	Stones	19.0	
R. Carrión	Ca1	23	1 300	13	12	Stones	18.5	
	Ca2	104	1 000	3.7	20	Stones	18.0	Below a dam
	Ca3	170	790	3.2	18	Stones	20.0	
R. Valderaduey	Va1	54	810	5	7	Stones	26.0	Summer drought
	Va2	188	650	1.6	7	Gravel	25.0	Channalized
R. Esla	El1	23	1 090	13	11	Stones	19.0	
	El2	76	870	4.2	32	Stones	19.0	
	El3	102	790	3.1	62	Gravel	20.0	
	El4	112	780	1	50	Gravel	21.5	
	El5	153	730	1.2	45	Gravel	21.5	
	El6	190	690	1.1	100	Gravel	23.0	
R. Cea	Ce1	42	900	3	10	Stones	18.0	
	Ce2	150	720	1.7	8	Gravel	22.0	
R. Porma	Po1	9	1 180	9	14	Stones	14.0	
	Po2	50	870	7.6	32	Stones	13.0	Below a dam
R. Bernesga	Be1	10	1 100	12	7	Stones	16.0	
R. Orbigo	Or1	12	1 200	13	25	Stones	14.0	
	Or2	70	880	5.5	41	Stones	16.0	Below a dam
	Or3	112	780	2.4	30	Gravel	22.0	
	Or4	170	740	0.7	35	Gravel	22.0	
R. Tera	Te1	30	900	11	14	Stones	18.0	Below a lake
	Te2	130	690	2.1	45	Gravel	24.0	Below dams
R. Riaza	Ri1	5	1 150	20	3	Stones	14.0	
	Ri2	116	770	3.4	7	Gravel	18.0	Below dams
R. Duratón	Dn1	13	1 000	8	6	Stones	23.0	Summer drought
R. Cega	Cg1	22	900	6	9	Gravel	23.0	Summer drought
	Cg2	142	690	1.8	11	Sand	25.0	Summer drought
R. Eresma	Er1	8	1 250	20	7	Stones	16.0	
	Er2	60	800	8.7	10	Stones	22.0	
	Er3	103	720	1.9	11	Sand	24.0	Summer drought
R. Adaja	Ad1	10	1 100	6	7	Gravel	19.0	Summer drought
	Ad2	72	860	2.4	10	Gravel	20.0	
	Ad3	170	690	1.7	23	Sand	27.0	Summer drought
R. Trabancos	Tr1	17	920	9	2	Sand	23.0	Summer drought
R. Tormes	To1	22	1 180	10	16	Stones	20.0	
	To2	102	850	4.1	27	Gravel	21.5	Below a dam
R. Huebra	Hu1	14	840	8	3	Stones	25.0	Periodical drought
R. Agueda	Ag1	13	810	12	15	Stones	24.0	

Fig. 2 represents the results of such an analysis. Although no clear structure can be detected, since many species of Plecoptera are present in most of the localities considered, some remarks on the relationships among species can be made by taking into account their relative positions among the localities.

Seven groups of species and localities can be differenciated in the figure and fitted into the zonation system of Illies & Botosaneanu (1963) as follows (Fig. 2) :

— G_0 : includes localities which correspond to the Crenon and Epirhithron, with swift current and soft waters. This zone is characterized by *Siphonoperla torrentium*, the spring-emerging *Leuctra* (*L. hippopus*) and *Amphinemura sulcicollis* which are all relatively frequent in the upper reaches of the rivers Riaza and Eresma, in the Guadarrama mountains.

— G_1 : includes the upper reaches of the main rivers studied, all of them oligotrophic and considered as Epirhithron. The Perlidae *Dinocras cephalotes*, *Perla marginata* and *Perla grandis* characterize this zone.

Although they are in the same group, *Dinocras cephalotes* is placed at a higher typological level than *Perla marginata* which is also abundant in other localities where a more tolerant species community exists. *Dinocras cephalotes* has been found only in the most oligotrophic sites, living in both lotic and lentic sections of the rivers. *Perla marginata* has been collected only in the sites exposed to the current. Some collections confirm the ecological distribution patterns of these two species described by Hynes (1941) and Berthélemy (1966), but others show the opposite. In the upper reaches of the river Ucero (Ucl) where there are huge populations of macrophytes, only *Perla marginata* has been recorded ; the upper reaches of the rivers Pisuerga (Pil), Esla (Ell), Porma (Pol) and Bernesga (Bel) have a substrate which is relatively unstable and is barely covered by moss ; *Dinocras cephalotes* is much more abundant there than *Perla marginata*.

— G'_1 : corresponds to the upper reaches of some rivers which harbour a macroinvertebrate fauna similar to those of localities situated at lower reaches in other rivers, no doubt because of the organic enrichment of the water or its higher temperatures. *Capnioneura* ssp. and *Protonemura meyeri* reach their largest densities in some of the stations in this group.

— G_2 : is represented by localities corresponding to the Metarhithron ; these always have a stony substrate on which some Perlidae and Perlodidae species live. Autumn-emerging *Leuctra* (*L.* gr. *fusca*) are also very common in this area.

— G_3 : this group contains localities belonging to the Hyporhithron. The species of Plecoptera relatively tolerant to organic enrichment inhabit this zone. Species of Taeniopterygidae and Capniidae are very common during the winter months.

— G'_3 : corresponds to the rivers situated in the south east of the basin which dry up in summer. Although some of these localities belong to the upper reaches of the rivers, they become very warm and have high conductivity in summer. Their fauna is therefore similar to that of other localities situated far downstream in other rivers.

Species of Taeniopterygidae and Capniidae are also very common in this area that can only support a Plecoptera fauna during winter. The biological cycle of these species, which are adult in early spring, is a very good strategy for colonizing such places where temperature and dissolved oxygen content limit the presence of other Plecoptera with later emerging periods.

— G_4 : represents the lowest region of the rivers studied in which Plecoptera exist. It corresponds to the Epipotamon ; it is clearly defined in winter when the Taeniopterygidae, the only Plecoptera in this zone, are abundant. *Brachyptera braueri* is the commonest and most characteristic species of the basin and is sometimes the only species of Plecoptera to occur.

4. — Discussion

In Fig. 2, the localities are spread along the first factorial axis following their altitudinal gradient, except in the cases mentioned above. *Dinocras cephalotes* and *Brachyptera braueri* are the species which contribute most to the first axis (15% and 40% respectively). Therefore the axis represents the « zonation » or the natural succession of localities from upstream downwards the rivers studied.

The influence of a variety of factors related to river zonation on the abundance and distribution of lotic insects has been pointed out many times (Hynes 1970, Hawkes 1975). The movement of the water, altitude and substrate control the distribution of sto-

Table II. Relative abundance of Plecoptera species considered in the factorial analysis in the Duero basin (aquatic samples and species which were present in at least five localities).

	Du1	Du2	Du3	Du4	Du5	Du6	Du7	Du9	Uc1	Uc2	Pi1	Pi2	Pi3	Pi4	As1	As2	Aa3	An1	An2	Eg1	Ca1	Ca2	Ca3	Va1	Va2	El1	El2	El3	El4
B. arcuata																		2											
B. braueri		1		7	7	8	3			1			6	5		8	7						6	6	4		6	6	4
B. monilicornis			8	2								1			3	3													
T. schoenemundi			3		1																		2	4		1		1	1
A. sulcicollis															1			4			5					1			
Nemoura ssp.																									1				
P. meyeri								1		1					1			1				1			1	1			
E. geniculata								1	3						1				1	3		1	5						
Leuctra ssp.(S)										3								1			2								
Leuctra ssp.(A)	5	2	4	1		2		1		1					5			6		2	5	4	4	4		3	4	1	
C. bifrons			3													1						2							
C. nigra																							3			5	3	1	
Capnioneura ssp.	1																												
Isoperla sp.		4	1		1			2	6						3				1		3	6				4			
P. microcephala		4																				1		4					
D. cephalotes	3									4					1			6			7	5				6			
P. bipunctata																			4							1	6	3	
P. grandis																					5						1		
P. marginata	7							4		1					1			7	3		5					4		1	
S. torrentium																					3								

	El5	El6	Ce1	Ce2	Po1	Po2	Be1	Or1	Or2	Or3	Or4	Te1	Te2	Ri1	Ri2	Dm1	Cg1	Cg2	Er1	Er2	Er3	Ad1	Ad2	Ad3	Tr1	To1	To2	Hu1	Ag1
B. arcuata												2		1			1					1							
B. braueri	3		8	6							4		3		1	4	5	1				6		4			1	4	
B. monilicornis		1	6								3	1	4																3
T. schoenemundi			3			3			2						6		1									1			
A. sulcicollis					2		1					1		3					3							2			
Nemoura sp.												1					3					4						6	
P. meyeri						1						3					1												
E. geniculata			4			3				3		1	1		2							1							
Leuctra ssp.(S)					4		3	1						3					3			1				1			1
Leuctra ssp.(A)			3		2	5	3	3	4		1				2				1										
C. bifrons			1	1			1				1					3	1				1	7	1	1	1				
C. nigra								1	3																				
Capnioneura sp.											1	1		1								2							5
Isoperla sp.			2		3	3		7	7			4			1	1	3	3			3	6		3				5	
P. microcephala			3						2			2				2	1				1			1		3			
D. cephalotes			1		7	6	7	8	4					2					6	1									
P. bipunctata						3			7				1																
P. grandis			1				1	1	1																				
P. marginata			6				1		2																				
S. torrentium								1																					

Species also present in the Duero Basin, collected as adult or in less than five localities:

Brachyptera auberti, Brachyptera vera, Rhabdiopteryx thienemanni, Nemoura cinerea, Nemoura fulviceps, Nemoura lacustris, Protonemura intricata iberiaca, Protonemura pyrenaica, Leuctra alosi, Leuctra castillana, Leuctra fusca, Leuctra hippopus, Leuctra hispanica, Leuctra madritensis, Leuctra marocceana, Leuctra occitana, Capnioneura libera, Capnioneura mitis, Hemimelaena flaviventris, Perla burmeisteriana, Chloroperla tripunctata.

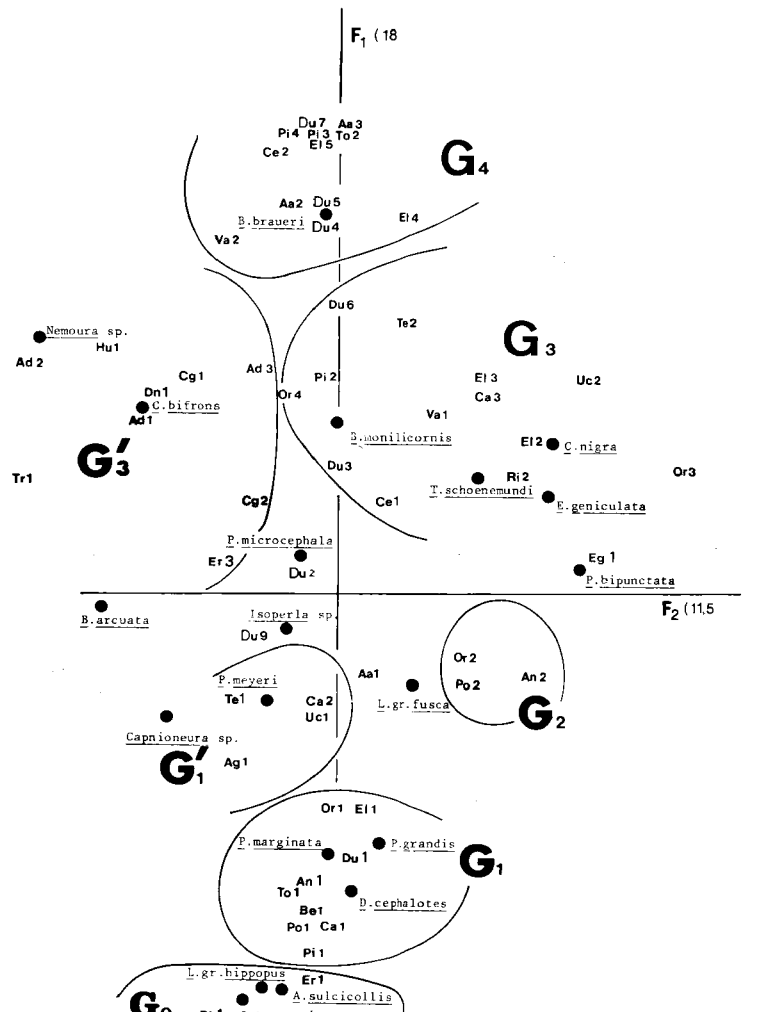

Fig. 2. Factorial analysis of Plecoptera fauna in the Duero basin (Spain).

nefly nymphs in some areas (Hynes 1941, Brinck 1949, Berthélemy 1966) and temperature and food are considered as primary factors in others (Kamler 1965, Lillehammer 1974, Ward 1982).

In Fig. 2, the localities with turbulent current and stony substrates are located towards the negative values of the first factorial axis and the ones with uniform water flow and gravel or sandy bottom are situated at the opposite, towards the positive end of the axis. It seems that these parameters, viz. current and substrate, are those most correlated to the first axis (which represents the « zonation ») and they can be considered as the major factors controlling the distribution of the plecopteran fauna in the Duero basin.

The second factorial axis seems to be determined by the distribution of some species which inhabit only the northern slope of the basin, such as *Capnia nigra*, *Euleuctra geniculata* and *Perla bipunctata*, and of others which are more abundant in the southern areas such as *Nemoura* sp. and *Capnia bifrons*. The factors which most differenciate these two slopes are temperature (much lower in the north) and drought (relatively frequent in the south).

The influence of drought on stonefly nymphs distribution has been stated before (Hynes 1941). It seems that the factors mentioned are those that determine the structure of the Plecoptera communities although each one takes a different relative weight according to the natural characteristics of the area.

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