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MAYFLIES AND STONEFLIES FROM THE RIO MONACHIL (SIERRA NEVADA, SPAIN) (Ephemeroptera and Plecoptera)

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ABSTRACT

Seasonal sampling was carried out in the Río Monachil, a high mountain stream, from November 1985 to August 1986. Populations of mayflies and stoneflies along the river course and the influence of pollution from a ski resort situated on the headwaters and from populations along the river are discussed.

INTRODUCTION

The source of the Río Monachil stream is at 2600 m a.s.l.; along its median course it goes through several small towns and it finally flows into the left bank of the Genil river, at 650 m a.s.l., below the city of Granada (fig. 1). Pollution is found in the headwaters by water waste from a ski resort and along the median and lower reaches. This stream has a snow dependent flow regime (PULIDO, 1980), steep profile, narrow bed, shallow waters and stony substrata, so that muddy margins are very scarce, and are only present at lower altitudes.

MATERIAL AND METHODS

Sampling was conducted at 9 stations along the stream (1: 2570 m, U.T.M.: 30SVG6503; 2: 2160 m, U.T.M.: 30SVG6404; 3: 2050 m, U.T.M.: 30SVG6405; 4: 1470 m, U.T.M.: 30SVG6006; 5: 1080 m, U.T.M.: 30SVG5508; 6: 790 m, U.T.M.: 30SVG5109; 7: 730 m, U.T.M.: 30SVG4610; 8: 690 m, U.T.M.: 30SVG4711 and 9: 650 m, U.T.M.: 30SVG4513) (fig. 1).

Every station was sampled seasonally from November 1985 to August 1986. The central and marginal zones were considered separately for sampling, and a Surber sampler (0.36 mm mesh size) was used for consecutive samples, until a length of two meters had been covered. Also an additional qualitative sampling was done with a hand net (1 mm mesh size) in every microhabitat. Simultaneously different physical and chemical parameters were analysed and the general characteristics of the river bed were noted. Sampling station 1 was sampled only during summer when it was not covered by snow and qualitative data from it are not discussed. The sampling station 9 was contaminated and no macroinvertebrates inhabited there.

RESULTS

Water temperatures fluctuated during the study, with winter minimum and summer maximum, as follows: between 3.5 and 11 °C in the head waters (sampling stations 1 to 3), between 5.5 and 19 °C in the middle course (sampling stations 4 to 6) and between 7 and 21.5 °C in the lower reaches (sampling stations 7 and 8). Measures of pH values were close to 7 in head waters (with an annual average of 7.02), increasing slightly in the lower reaches (with an annual average of 7.73 in the middle course and 8 in the lower course).

Although the oxygenation rate was good (saturation between 57 and 139 %), a clear decrease from headwaters to the mouth was observed. In contrast, mineralization increased from the upper to lower course; lowest values were found during the snowmelt in late spring (40 µS/cm) and highest (about 700 µS/cm) in autumn (sampling station 9).

The waters were polluted in the lower course close to the mouth and in the headwaters, below the ski resort, with seasonal variations; thus in winter and spring (coinciding with the ski season) the worst situation was observed in the headwaters (Zamora-Muñoz and Alba-Tercedor, 1991).

The vegetation was of bryophytes, and semi-submerged macrophytes at the margins, but there were only algae in the headwaters.

Twelve stonefly species (1280 specimens) and seventeen mayfly species (11784 specimens) were caught.

From the quantitative data, the numerical importance of both Plecoptera and Ephemeroptera nymphs in the aquatic macroinvertebrate community was plotted along the profile of the stream (fig. 2).

Altitudinal distribution and abundance of the various species along the profile of the Río Monachil stream is presented both annually (figs. 3 and 4) and separately for each season (tables 1 and 2).

At present it is not possible to distinguish between the nymphs of *Epeorus sylvicola* and *E. torrentium* (Berthélemy and Thomas, 1967; Alba-Tercedor, 1981) and, as both species are distributed in the Sierra Nevada (Alba-Tercedor, 1981) and no adults were collected during this study, they are considered together.

DISCUSSION

Among aquatic macroinvertebrates, the most numerous group was the mayfly nymphs, with a percentage of total catches between 20 % in the median-low reaches and 63.4 % in the upper reaches (average of 44.6 %).

However the highest percentage of stonefly populations (9.3 %) occurred in the upper reaches (average sites with the presence of Plecoptera was 3.3 %).

The importance of mesh size and handling of the net in sampling macroinvertebrates has been considered in several studies (*i.e.*, Hynes, 1970; Macan, 1974; Ward, 1984). Sampling effectivity with the small net (with coarse mesh) was higher for plecopteran nymphs than the Surber sampler (with fine mesh); but this did not occur for mayflies, where more species were collected by the Surber sampler (figs. 3 and 4). Because most mayfly nymphs are better swimmers than the stoneflies, they can escape more easily from the small hand net than from the bottom of a Surber sampler, and since stonefly populations are scarcer than those ofthe mayflies greater numbers of species were collected as the number of microhabitats that were sampled increased. However the richest number of species was obtained with a combined sampling where both nets methods were involved.

As altitude decreased, populations of both mayflies and stoneflies declined (fig. 2); but while this occurred in number of Plecoptera species (that disappeared below the sampling station 7, where in summer 21.5 °C were recorded) (fig. 3), the highest number of Ephemeroptera species was found in the median-lower reaches (sampling stations 5 to 7) (fig. 4), in accordance with previous observations of several authors (Hynes, 1970). Moreover below altitudes close to 1500 m some altitudinal replacements of related species were observed; thus *Perla marginata* replaced *P. grandis*, and *Isoperla grammatica* a *I. nevada*. In the same way, because of different adaptations to mineralization of the water (Alba-Tercedor, 1983), populations of *Baetis alpinus* were numerous in the upper reaches of the stream, but lower the altitude, the lower was the number of catches, and higher the populations of *B. maurus* occurred; and it finally replaced *B. alpinus* (fig. 4).

During this study the effect of pollution was observed as clearly decreasing the populations, because of the inflow of sewage from the ski resort (sampling station 3) (fig. 3 and 4), and below sampling station 6, where an input of additional sewage from small towns and the city of Granada occur (figs. 3 and 4). However, when studying seasonal longitudinal abundance and distribution, it was observed that abundance and the number of species in winter and spring (tables 1 and 2) decreased in comparison with summer and autumn. It was at first assumed that this was due to the pattern in the life cycles of species, but after considering previous studies (Alba-Tercedor, 1981, 1983b, 1986, 1990; Sánchez-Ortega, 1986; Sánchez-Ortega and Alba-Tercedor, 1990) it can be attributed only to the effects of pollution.

Even though sewage discharges of the ski resort increased in winter and spring, the sensitivity of mayflies and stoneflies to pollution was so high that a decrease of their populations could also be observed at sampling station 3 and even at sampling station 4 (table 1) during summer and autumn.

Studying the distribution of species in accordance with the water quality situation of the Río Monachil stream during the sampling period (Zamora-Muñoz and Alba-Tercedor, 1991), with respect to the rate of tolerance to organic pollution, four groups can be distinguished: a) "intolerant species":

Capnia nigra, Leuctra fusca, Amphinemura triangularis, Isoperla grammatica, Baetis scambus, Ephemerella ikonomovi nevadensis, Rhithrogena gr. *hybrida* and *R. marcosi*; b) "slightly tolerant species": *Perla marginata, P. grandis, Dinocras cephalotes, I. nevada, Perlodes microcephala, B. fuscatus, B. maurus, B. muticus intermedius, B. pavidus, Cloeon cognatum, Caenis luctuosa, E. ignita, Ecdyonurus* sp., *Epeorus sylvicola/torrentium* and *R.* gr. *semicolorata*; c) "tolerant species": *L. inermis, Protonemura alcazaba, P. meyeri, B. alpinus* and *B. vernus*; and the mayfly nymphs of *B. rhodani* were "very tolerant".

Our conclusions on the known behaviour of stonefly and mayfly species, with respect to pollution outlined above, agree in general terms, with the results of previous studies carried out in Spain (González del Tánago and Garciá del Jalón, 1984; Garciá de Jalón and González del Tánago, 1986; Puig, 1984) and in other European countries (see Hellawell, 1986). However *P. marginata* and *B. alpinus*, are considered as intolerant species in more northern latitudes (González del Tánago and Garciá de Jalón, 1984; Garciá de Jalón and González del Tánago, 1986; Hellawell, 1986). The first species inhabited slightly polluted waters in the Monachil as in other streams of the Sierra Nevada mountains (Alba-Tercedor and Jiménez-Millán, 1987; Alba-Tercedor *et al.*, in press), while *B. alpinus* behaved as a tolerant species in the Río Monachil. Furthermore *R. marcosi* behaved as an intolerant species in this study, but in the Río Adra basin (also in the Sierra Nevada mountains), it was observed inhabiting slightly polluted waters (Alba-Tercedor. *et al.*, in press).

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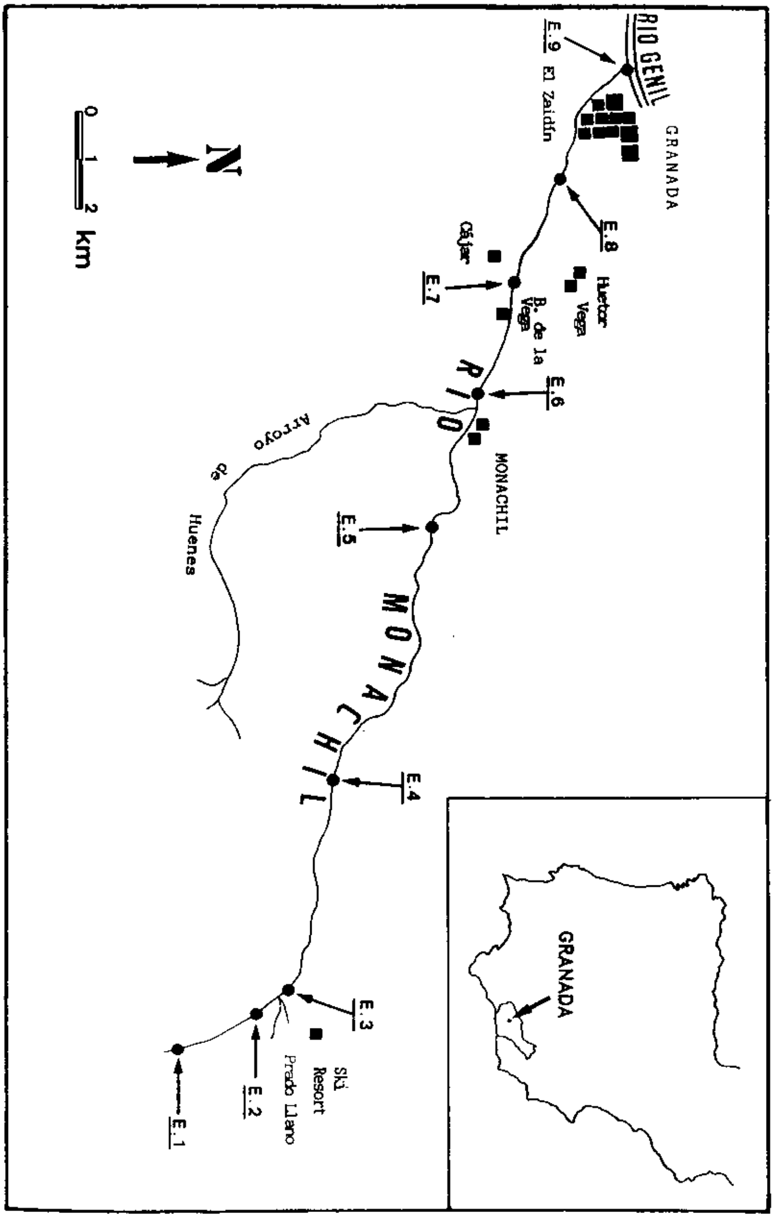

Fig. 1. Course of the Río Monachil stream, with sampling stations locations.

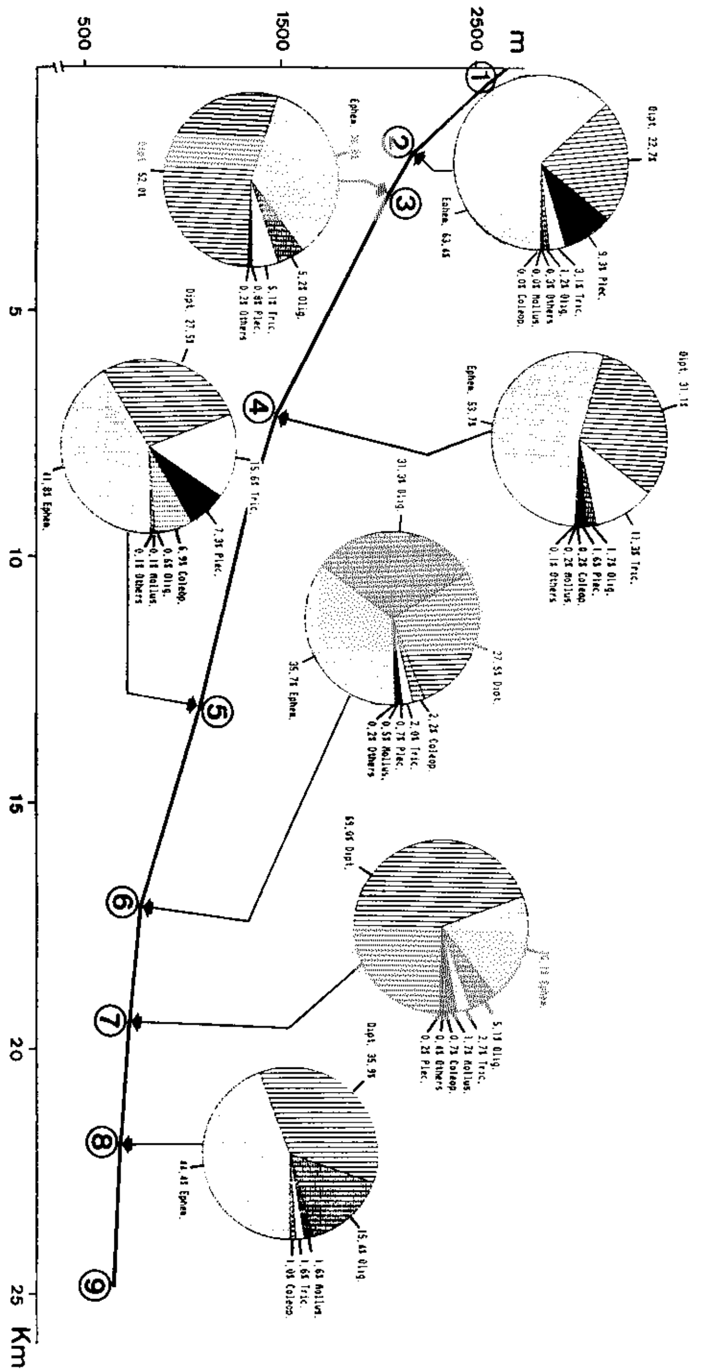

Fig. 2. Numerical percentages of different macroinvertebrate groups in the aquatic community along the profile of Río Monachil stream.

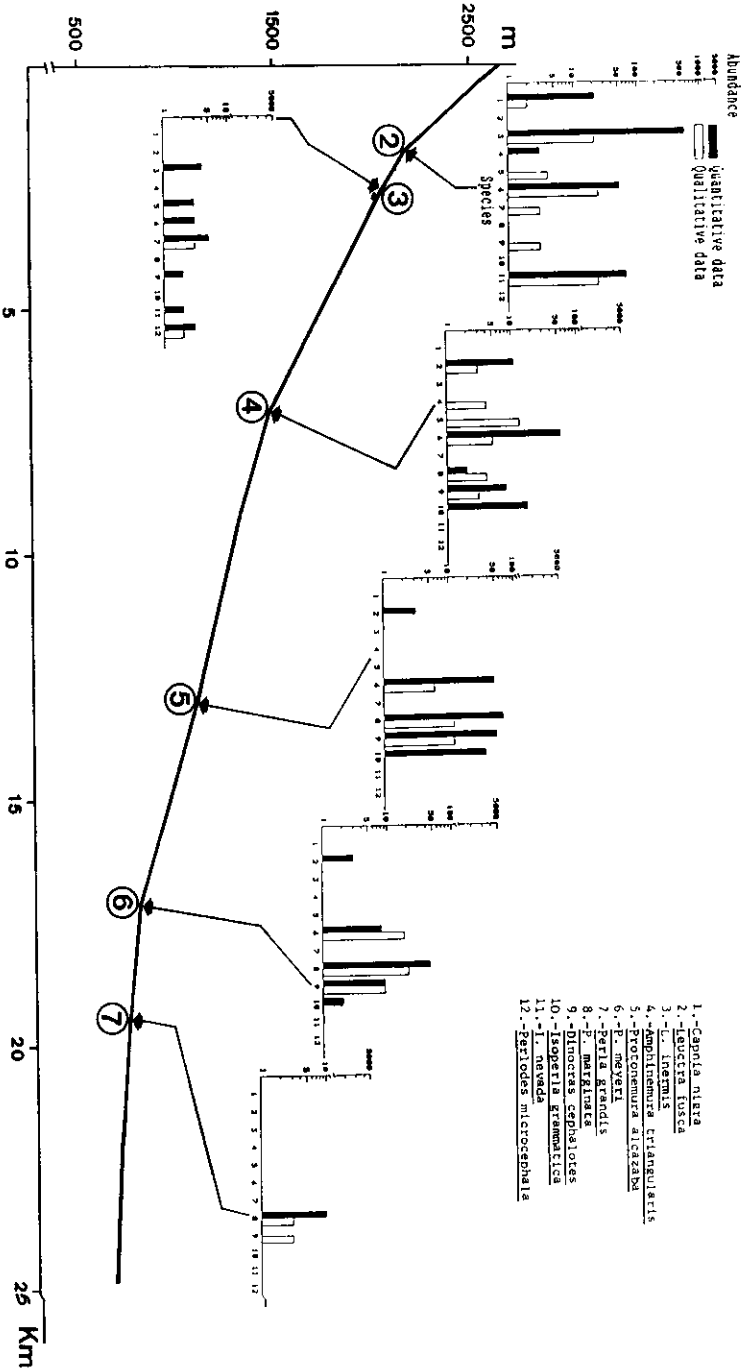

Fig. 3. Distribution along the profile of the plecopteran species, using assembled data from the annual cycle studied. Abundance it is expressed as log (number of specimens + 1).

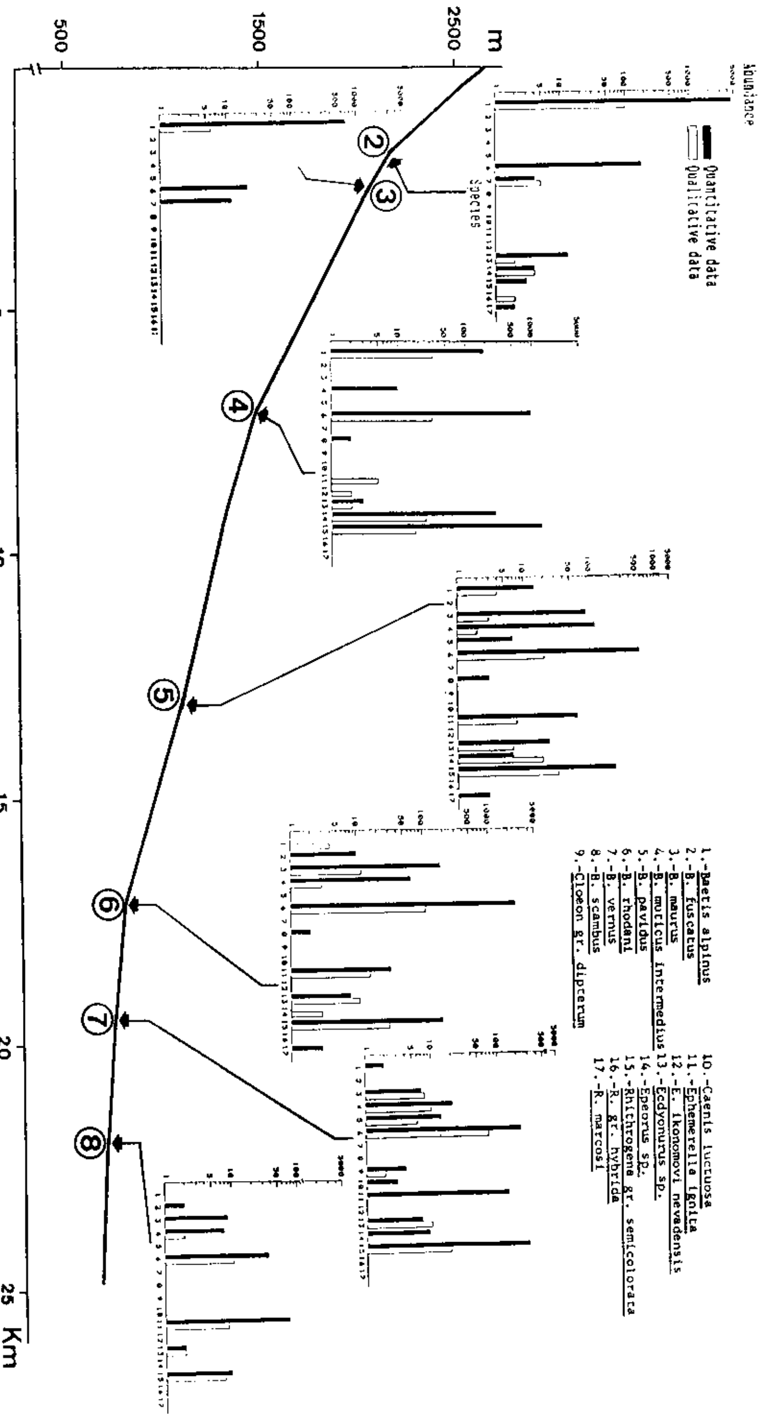

Fig. 4. Distribution along the profile of the ephemeropteran species, using assembled data from the annual cycle studied. Abundance it is expressed as log (number of specimens + 1).

Sampling stations:	S - 2				S - 3				S - 4				S - 5				S - 6				S - 7				S - 8				S - 9			
	AUT	WIN	SPR	SUM	AUT	WIN	SPR	SUM	AUT	WIN	SPR	SUM	AUT	WIN	SPR	SUM	AUT	WIN	SPR	SUM	AUT	WIN	SPR	SUM	AUT	WIN	SPR	SUM	AUT	WIN	SPR	SUM
Baetis alpinus	1624	246	45	2684	323	17	-	343	35	77	7	73	-	10	4	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-
B. fuscatus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	-	1	-	-	-	-	-
B. maurus	-	-	-	-	-	-	-	-	-	-	-	-	80	-	-	8	13	149	2	21	-	1	6	-	-	-	8	-	-	-	-	-
B. muticus intermedius	-	-	-	-	-	-	-	-	8	1	-	1	77	8	12	24	-	56	4	6	3	-	14	3	-	-	7	-	-	-	-	-
B. pavidus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	-	-	-	-	12	-	-	1	-	-	-	-	-	-	-	-
B. rhodani	-	-	-	161	1	-	-	19	572	5	2	428	297	42	1	237	1313	728	8	484	87	122	6	13	1	29	6	-	-	-	-	-
B. vernus	-	-	3	-	-	-	-	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
B. scambus	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	2	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
Cloeon gr. dipterum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	1	-	-	-	-	-	-	-	-
Caenis luctuosa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-
Ephemerella ignita	-	-	-	-	-	-	-	-	-	-	-	-	-	-	61	5	-	-	24	8	-	-	148	-	-	-	74	-	-	-	-	-
Ecdyonurus sp.	11	1	-	-	-	-	-	-	2	-	-	-	12	10	3	-	6	1	-	-	1	-	4	1	1	-	-	-	-	-	-	-
Epeorus sylvicola/torrentium	-	3	-	-	-	-	-	-	134	152	1	-	5	-	1	-	-	-	-	-	-	-	8	-	-	-	-	-	-	-	-	-
Rhithrogena gr. semicolorata	-	2	-	-	-	-	-	-	1244	161	8	1	211	11	20	-	-	1	199	-	-	-	296	-	-	-	9	-	-	-	-	-
R. marcosi	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-

Table 1. Total number of Plecoptera nymphs caught by a Surber sampler along the Río Monachil in each sampling station.

Sampling stations:	S - 2				S - 3				S - 4				S - 5				S - 6				S - 7				S - 8				S - 9			
	AUT	WIN	SPR	SUM	AUT	WIN	SPR	SUM	AUT	WIN	SPR	SUM	AUT	WIN	SPR	SUM	AUT	WIN	SPR	SUM	AUT	WIN	SPR	SUM	AUT	WIN	SPR	SUM	AUT	WIN	SPR	SUM
Capnia nigra	19	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Leuctra fusca	-	-	-	-	-	-	-	-	9	-	-	1	1	-	-	1	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-
L. inermis	203	358	1	-	1	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Amphinemura triangularis	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Protonemura alcazabe	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
P. meyeri	24	23	-	4	2	-	-	-	53	1	-	1	37	1	-	11	-	3	-	4	-	-	-	-	-	-	-	-	-	-	-	-
Perla grandis	-	-	-	-	3	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
P. marginata	-	-	-	-	-	-	-	-	1	-	-	-	25	2	19	20	2	-	4	39	-	1	8	-	-	-	-	-	-	-	-	-
Dinocras cephalotes	-	-	-	-	1	-	-	-	7	-	-	-	7	2	3	40	-	-	1	7	-	-	-	-	-	-	-	-	-	-	-	-
Isoperla grammatica	-	-	-	-	-	-	-	-	15	-	-	1	35	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
I. nevada	38	26	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Perlodes microcephala	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 2. Total number of Ephemeroptera nymphs caught by a Surber sampler along the Río Monachil in each sampling station.