

Ephemeroptera and Plecoptera in the Chiascio River (Central Italy) since a dam's building

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Abstract

The aim of this study is the characterization of the distribution of Ephemeroptera and Plecoptera along the Chiascio River (tributary of the Tiber River, Central Italy) in response of the dam's building. Thirteen taxa of Ephemeroptera and seven taxa of Plecoptera were identified. Ubiquitous species: *Leuctra* sp., *Baetis rhodani*, *Baetis* sp., *Caenis* gr. *macrura* and *Serratella ignita* were found most frequently. The similarity dendrogram defined two large clusters of stations (upstream and downstream of the dam) characterized by different subsets of Ephemeroptera taxa. The results concur with the *river continuum* model, except for the obvious discontinuity due to the dam. The reservoir on the Chiascio River causes or aggravates unfavourable changes in the Ephemeroptera community in the stream.

Keywords: mayfly, stonefly, running waters, functional feeding groups, benthic environment.

Introduction

Among freshwater macroinvertebrates, Plecoptera are generally considered the most sensitive taxon to organic pollution and oxygen deficiency, while Ephemeroptera are in second place on the scale of sensitivity to environmental stress (e.g. Woodiwiss, 1964, 1978, 1981; Ghetti and Bonazzi, 1981; Ghetti, 1997; Vernaux and Tuffery, 1967; Vernaux *et al.*, 1978; Chandler, 1970; Alba-Tercedor and Sanchez-Ortega, 1988; Armitage *et al.*, 1983).

Most stonefly nymphs are restricted to cool lotic waters while those of mayflies have a broader ecological range with a preference for warmer lotic waters (Wiggins and Mackay, 1978).

In their immature stages, stoneflies and mayflies show trophic complementarity which permits a comprehensive trophic vision of the lotic system. In fact, the former are basically shredders or predators while the latter are mainly collectors and scrapers (Wiggins and Mackay, 1978).

Therefore, these two insect orders can be used as bioindicators of the water quality and trophism of streams, and they also provide important faunal information in a given territory. This is particularly true for the Ephemeroptera (Buffagni, 1997).

In the benthic invertebrate community of the Chiascio River, the Trichoptera have been well studied (Moretti *et al.*, 1993; 1997) but there is very little information about Plecoptera (part of the area is included in the vast territory investigated by Consiglio, 1971) and Ephemeroptera; for the last ones, studies refer to the terminal part of the river (Moretti *et al.*, 1976).

The aim of the present study is the characterization and analysis of the distribution of Ephemeroptera and Plecoptera along the Chiascio River (Central Italy) before the complete filling of the reservoir built at about 50 km along its course (the work was begun in 1980). The dam of the Chiascio Reservoir was constructed as part of a large irrigation scheme (Di Giovanni *et al.*, 1996) involving about 65,000 ha in Central Italy; it serves a catchment area of 471 km² and, when full, the lake will stretch along the narrow valley for about 20 km, with a water volume of 0.224 km³ (E.A.B.I.V.F., 1991). At the moment, the reservoir is only partially filled in late spring and the water is released when the river is low (summer) to increase its flow.

Material and Methods

Study area

The Chiascio River (Fig. 1), a left-bank tributary of the Tiber River, is 95 km long; it presents a highly variable water regime and has a catchment area of 1,956 km² of which 62% belongs to its main tributary: the Topino River (Mearelli *et al.*, 1996).

Thirteen sampling stations were selected for collection of material for the benthic investigation (Fig. 1). For better a definition of the macrobenthos habitat, certain characteristics of the stations are reported in Table 1. Physico-chemical analyses were performed at each station in the period which the river was low (Summer). The lowest values of dissolved oxygen were observed at station 7 (7.93 mg/l) and station 13 (8.13 mg/l).

Sampling and methods

The investigation of the immature stages of Ephemeroptera and Plecoptera consisted of two seasonal sampling campaigns (phase I:1996-97, st.1-7; phase II:1998-99, st.8-13). The sampling time was limited to 10 minutes per kick-sample, supplemented by collecting from submerged stones and vegetation. The samples were collected with a 0.335 mm mesh (21/cm) dragnet by means of semi-quantitative samplings, transported to the laboratory in plastic containers, sieved, separated and fixed in 70-80% alcohol.

The Sorensen Index of Similarity (Sorensen, 1948), $S = 2c / (a + b)$, where *a* is the number of taxa in sample *A*, *b* is the number of taxa in sample *B* and *c* is the number of taxa common to the two samples, was adopted to assess the degree of similarity of taxa of paired stations: 0 = no species in common, 1 = all species in common. As this coefficient takes into account only the

presence/absence of taxa, it provides a qualitative interpretation.

Differences among stations were graphically represented by a dendrogram constructed with the unweighted pair-group method using arithmetical averages (UPGMA) (Sneath and Sokal, 1973).

A functional feeding analysis (Cummins and Wilzbach, 1985) applied to the macrobenthic populations was based on ln(x+1) transformed abundance values. This method was selected because it seemed to be appropriate for investigation of the trophism of the biocenotic components in a situation where only semi-quantitative samples were available.

The data were subjected to further statistical testing by correspondence analysis (CA) to establish associations among variables.

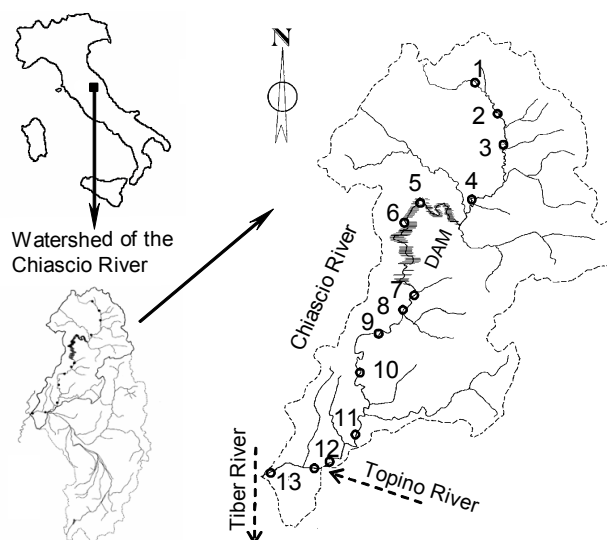


Fig. 1 - Map of the Chiascio River watershed showing the 13 sampling stations.

Tab. 1 – Some main environmental parameters (min. – max values) of the 13 sampling stations.

	Phase I: 1996-1997							Phase II: 1998-1999					
	St. 1	St. 2	St. 3	St. 4	St. 5	St. 6	St. 7	St. 8	St. 9	St. 10	St. 11	St. 12	St. 13
Altitude (m a.s.l.)	447	420	400	382	315	300	260	251	241	207	195	180	173
Stream depth (cm)	12.0 - 30.0	30.0 - 43.0	18.0 - 35.0	15.0 - 35.0	30.0 - 60.0	35.0 - 65.0	30.0 - 280.0	30.0 - 150.0	40.0 - 150.0	15.0 - 100.0	25.0 - 150.0	40.0 - 120.0	70.0 - 150.0
Stream width (m)	2.5 - 4.0	4.0 - 4.5	6.0 - 7.7	8.5 - 12.0	7.5 - 18.0	10.0 - 17.5	6.0 - 16.5	14.0 - 17.0	12.0 - 14.0	11.0 - 22.0	8.0 - 15.0	17.5 - 24.0	20.0 - 20.0
pH	8.3 - 8.6	8.3 - 8.6	8.4 - 8.6	7.9 - 8.8	8.0 - 8.6	8.5 - 9.4	8.5 - 9.4	8.1 - 8.3	8.1 - 8.4	8.0 - 8.4	8.2 - 8.5	8.2 - 8.3	8.0 - 8.4
Water temperature (°C)	6.5 - 18.0	7.0 - 17.0	8.0 - 18.0	9.0 - 20.0	8.5 - 21.5	9.0 - 22.5	9.0 - 22.0	4.5 - 21.5	5.0 - 21.5	4.8 - 22.5	5.0 - 24.0	5.0 - 23.0	6.0 - 21.5
Air temperature (°C)	9.0 - 22.0	10.0 - 23.0	10.0 - 22.0	12.0 - 27.0	12.0 - 28.0	12.0 - 28.0	10.5 - 28.0	3.0 - 24.0	5.0 - 24.0	3.0 - 27.0	6.5 - 27.0	11.0 - 27.0	11.0 - 29.5

Results

The sampling yielded 13 taxa of Ephemeroptera with 11,088 specimens and 7 taxa of Plecoptera with 1,445 specimens. Table 2 reports the distribution in abundance classes of the species at the stations.

Station 1 (ca. 10 km from the source) is the richest in taxa for both orders and also has the

highest number of individuals for Plecoptera, while station 4 has the highest number of individuals for Ephemeroptera (Fig. 2). Plecoptera were never recovered in the terminal part of the river (stations 12 and 13) while *Leuctra* sp. is the most abundant taxon at the other stations. *Baetis rhodani* (PICTET, 1843), *Baetis* sp., *Caenis* gr. *macrura* and *Serratella ignita* (PODA, 1761) are

present at all the stations while the other Ephemeroptera colonize upstream and downstream tracts in a different manner.

In all seasons, the distribution of Ephemeroptera shows strong discontinuity at station 7 with a marked numerical reduction. This situation is much less evident for Plecoptera which are poorly present already at station 4 (Fig. 2).

For Ephemeroptera, the cluster analysis obtained from the similarity matrix applied to the values of the Sorensen Index (1948) reveals two environmental conditions of the river, divided at the reservoir (just upstream of station 7): a tract between stations 1-6 and a tract between stations 7-13. This is not so evident for Plecoptera, also because of their low abundance from station 4 onward (Fig. 3).

Correspondence analysis of the numerical abundance of the taxa (log transformed) and the populations to the stations shows an upstream-downstream gradient for Ephemeroptera, with some taxa characteristic of certain river zones and other typically ubiquitous taxa. Station 7, downstream of the dam, behaves in an independent way. For the Plecoptera, there is a similar trend and the position of station 7 in the Euclidean space, is separate from the other stations (Fig. 4).

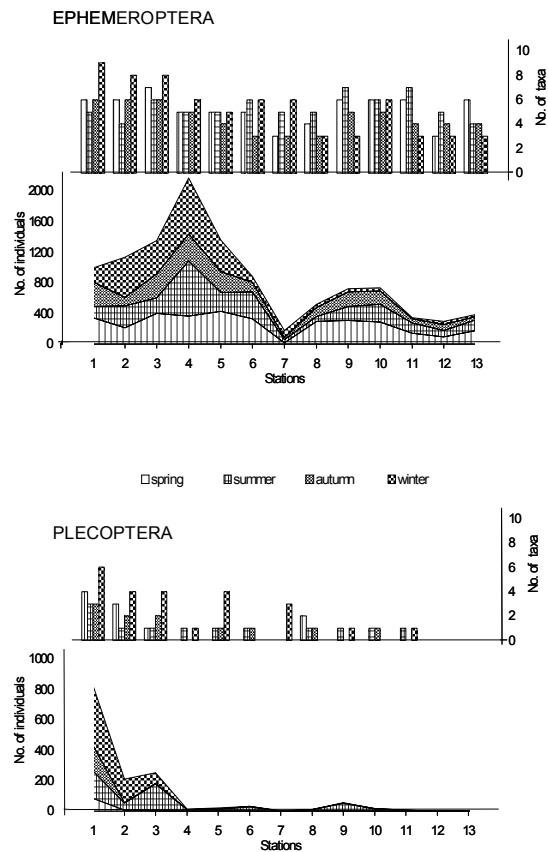


Fig. 2. Seasonal distribution at the sampling stations (specimens and taxa).

EPHEMEROPTERA

	st1	st2	st3	st4	st5	st6	st7	st8	st9	st10
st1	—	9	8	9	6	8	7	5	7	6
st2	0.95	—	8	8	6	8	7	5	7	6
st3	0.84	0.89	—	7	6	8	6	4	6	6
st4	0.95	0.89	0.78	—	6	7	7	5	7	6
st5	0.75	0.8	0.8	0.8	—	6	5	4	6	5
st6	0.89	0.94	0.94	0.82	0.86	—	6	4	6	5
st7	0.82	0.88	0.75	0.88	0.77	0.8	—	5	6	6
st8	0.63	0.67	0.53	0.67	0.67	0.57	0.77	—	6	6
st9	0.78	0.82	0.71	0.82	0.86	0.75	0.8	0.86	—	7
st10	0.63	0.67	0.67	0.67	0.67	0.59	0.75	0.8	0.82	—
st11	0.71	0.75	0.63	0.75	0.77	0.67	0.86	0.92	0.93	0.88
st12	0.53	0.57	0.57	0.57	0.73	0.62	0.67	0.91	0.77	0.71
st13	0.75	0.8	0.67	0.8	0.83	0.71	0.92	0.83	0.86	0.8

PLECOPTERA

	st1	st2	st3	st4	st5	st6	st7	st8	st9	st10	st11	st12	st13
st1	—	4	4	2	4	1	2	3	2	1	2	-	-
st2	0.80	—	4	2	3	1	2	2	2	1	2	-	-
st3	0.80	1.00	—	2	3	1	2	2	2	1	2	-	-
st4	0.50	0.67	0.67	—	1	1	1	1	2	1	1	-	-
st5	0.80	0.75	0.75	0.33	—	0	2	2	1	0	1	-	-
st6	0.29	0.40	0.40	0.67	0.00	—	0	1	1	1	1	-	-
st7	0.44	0.57	0.57	0.40	0.57	0.00	—	1	1	0	0	-	-
st8	0.67	0.57	0.57	0.40	0.57	0.50	0.33	—	1	1	1	-	-
st9	0.50	0.67	0.67	1.00	0.33	0.67	0.40	0.40	—	1	1	-	-
st10	0.29	0.40	0.40	0.67	0.00	1.00	0.00	0.50	0.67	—	1	-	-
st11	0.50	0.67	0.67	0.50	0.33	0.67	0.00	0.40	0.50	0.67	—	-	-
st12	-	-	-	-	-	-	-	-	-	-	-	—	-
st13	-	-	-	-	-	-	-	-	-	-	-	-	—

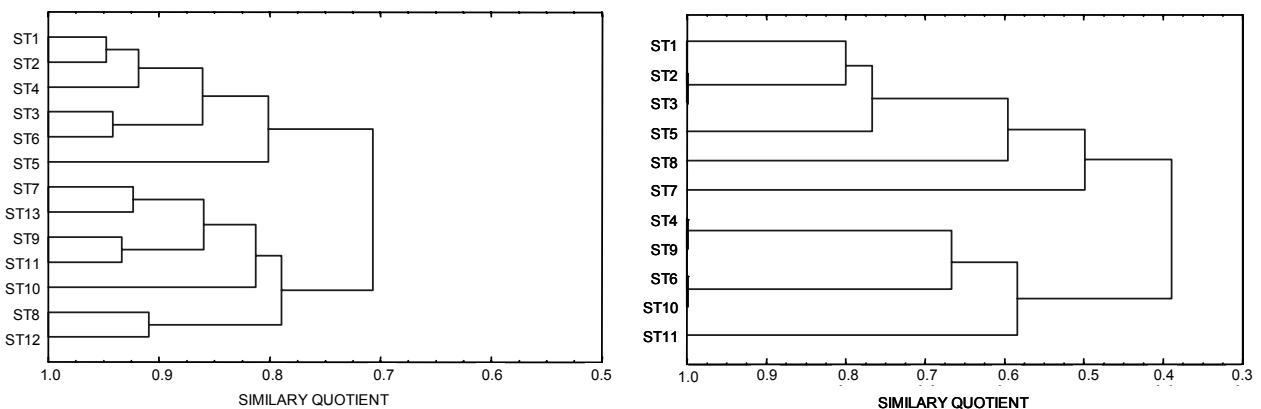


Fig. 3 - Triangular matrix, lower: values of the Sorensen Index of Similarity; Triangular matrix, upper: number of species common to successive stations. Cluster analysis dendrogram (UPGMA method) based on the Sorensen Index values.

Tab. 2 - Abundance nymphs and functional feeding groups (in parenthesis the secondary role) of Ephemeroptera and Plecoptera taxa at the sampling stations.

Taxa/Stations		1	2	3	4	5	6	7	8	9	10	11	12	13	
EPHEMEROPTERA															
No. of individuals: 11,088															
F.F.G.															
Baetidae															
<i>Acentrella sinaica</i> BOGOESCU, 1931	GC (Sc)	++	++	+	---	---	+	---	---	---	---	---	---	---	
<i>Baetis rhodani</i> (PICTET, 1843)	GC (Sc)	+++	++	++++	++++	++++	++	++	++	++	++	++	++	+++	
<i>Baetis</i> sp.	GC (Sc)	+++	+++	+++	+++	+++	+++	++	++	++	++	++	+++	++	
Caenidae															
<i>Caenis</i> gr. <i>macrura</i>	GC	+++	+++	+++	+++	+++	+++	++	+++	+++	+++	+++	++	++	
Ephemerellidae															
<i>Serratella ignita</i> (PODA, 1761)	GC	++	++	++	+++	++	++	++	++	++	++	++	++	++	
Ephemeridae															
<i>Ephemera</i> sp.	GC	---	---	++	---	---	---	---	---	---	+	---	---	---	
Heptageniidae															
<i>Ecdyonurus</i> sp.	GC - Sc	+++	+++	+++	++	++	++	++	---	++	++	++	---	+	
<i>Epeorus</i> sp.	GC - Sc	+	---	---	++	---	---	---	---	---	---	---	---	---	
<i>Heptagenia</i> sp.	GC - Sc	+	+	---	+	---	---	+	++	+++	+++	++	---	+	
Leptophlebiidae															
<i>Choroterpes picteti</i> (EATON, 1871)	GC	---	---	---	---	---	---	---	++	++	++	++	++	---	
<i>Habroleptoides</i> sp.	GC	++	++	++	+	---	+	+	---	---	---	---	---	---	
<i>Habrophlebia eldae</i> (JACOB & SARTORI, 1984)	GC	++	++	++	++	++	---	---	+	---	---	---	---	---	
<i>Paraleptophlebia submarginata</i> (STEPHENS, 1835)	GC	---	---	---	---	---	---	---	---	---	+	---	---	---	
PLECOPTERA															
No. of individuals: 1,445															
F.F.G.															
Perlodidae															
<i>Isoperla</i> sp.	P	+++	+++	++	---	+	---	+	+	---	---	---	---	---	
Perlidae															
<i>Perla marginata</i> (PANZER, 1799)	P	---	---	---	---	---	---	+	---	---	---	---	---	---	
Taeniopterygidae															
<i>Brachyptera risi</i> (MORTON, 1836)	Sc	++++	+++	+++	++	+	---	+	---	+	---	---	---	---	
Nemouridae															
<i>Nemoura</i> sp.	Sh	+	---	---	---	---	---	---	---	---	---	---	---	---	
<i>Protonemoura</i> sp.	Sh	+	---	---	---	+	---	---	++	---	---	---	---	---	
Capniidae															
<i>Capnia</i> sp.	Sh	+++	+++	++++	---	+++	---	---	---	---	---	---	+	---	
Leuctridae															
<i>Leuctra</i> sp.	Sh	+++++	++++	+	++	---	+++	---	++	+++	+++	+++	++	---	

---: absent; +: very rare (1-2 individuals); ++: rare (< 1% of individuals); +++: not abundant (1-5%); ++++: abundant (5-20%); +++++: very abundant (>20%)

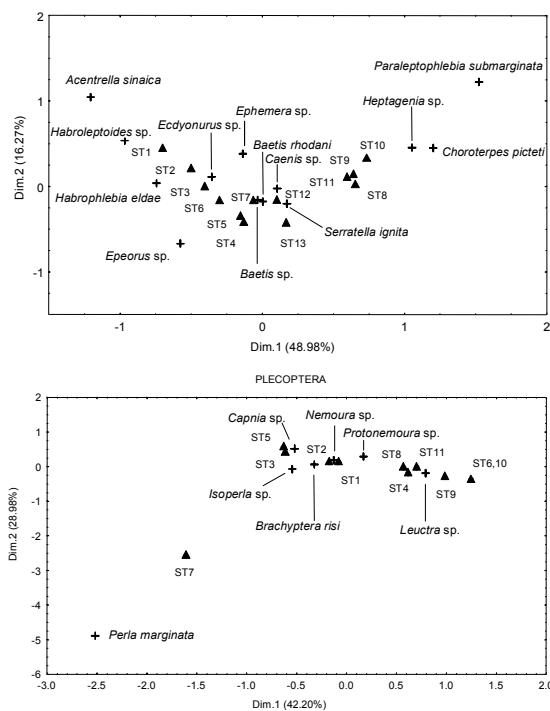


Fig. 4 - Correspondence analysis of species and sampling stations. Abundance values were ln(x+1) transformed.

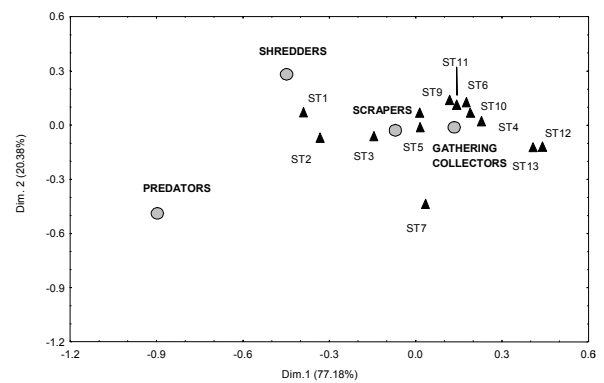


Fig. 5 - Correspondence analysis of Ephemeroptera and Plecoptera functional feeding groups and sampling stations. Values were ln(x+1) transformed.

Discussion

The abundance of *Baetis rhodani* (Janeva, 1979), the species of the *Caenis macrura*-group (Malzacher, 1986) and *Leuctra* sp. (Ghetti, 1997) along the river indicates a substantial organic load transported by the water.

The reservoir on the Chiascio River causes or aggravates unfavourable changes in the

Ephemeroptera fauna in the stream (Ward and Voelz, 1988) and the impoundment greatly contributes to fragmentation of the *river continuum* (Perry and Schaeffer, 1987).

Correspondence analysis of the trophic categories of the 20 taxa shows a strong association between Shredders (Sh), Predators (P) and the upstream part of the river, and an association between Gathering Collectors (GC) and the downstream stations (Fig. 5). Sh and P are represented only by Plecoptera and GC only by Ephemeroptera, while Scrapers (Sc) include taxa belonging to both orders.

The associations between the river zones and the trophic categories agree with the *river continuum* model (Vannote *et al.*, 1980; Cummins *et al.*, 1984.). The only exception is that between Predators and the upstream part of the river, due to the fact that *Perla* and *Isoperla*, the only predator taxa of the community examined, are absent in the downstream zone.

Moreover, in the Euclidean space of Fig. 5, one can observe the effect of the reservoir on the benthic community downstream of the dam (Ward and Voelz, 1988). In the second axis (about 20% of the total variance), station 7 is separate from the other stations, both in the downstream and upstream tracts, indicating a discontinuous composition of the trophic groups.

In synthesis, monitoring of the Plecoptera and Ephemeroptera benthic community allows one to study the time-course of water pollution (organic) and morphological alteration of the Chiascio River system.

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