LONGITUDINAL DISTRIBUTION OF THE MAYFLY (EPHEMEROPTERA) COMMUNITIES AT THE CHOCANCHARAVA RIVER BASIN (CÓRDOBA, ARGENTINA)

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ABSTRACT

Distribution of Ephemeroptera communities in the longitudinal gradient of Chocancharava river basin was studied. Species and sample ordination was performed by means of DCA (Detrented Correspondence Analysis). Fourteen species of Ephemeroptera belonging to six families were collected. Sites with higher species richness were foothill stretches. There was an indication of distinct rhithron and potamic assemblages. There is a gradual change in abundance downstream and substitution of species along elevation gradients from mountain to lowland rivers, with a major discontinuity under conditions of environmental stress, as pollution and hydraulic shifts.

INTRODUCTION

Ephemeroptera larvae are major components of fluvial ecosystems in Córdoba Province (Corigliano *et al.*, 1996), and contribute significantly to zoobenthic biomass and are the main food resources for insectivore fishes in mountain streams (Corigliano y Malpassi, 1994).

In spite of their ecological importance there is a shortage of knowledge about basic issues such as distribution in longitudinal gradients and ecological requirements in stream and rivers of Córdoba Province. Besides, specific status of immature stages of the regional fauna has not been completely developed yet. There is a dubious species, *Paracloeodes* sp. not reported by Domínguez *et al.*, (1994). But meanwhile taxonomic research develops, it is necessary to make some ecological considerations about the taxa to understand their functional role in river ecology.

Questions about patterns of altitudinal distribution of invertebrates are of main interest in fluvial ecology. Whether species distribution is zonal (Illies and Botosaneanu, 1963) or continuous (Vannote *et al.*, 1980) and what the importance of boundaries (Naiman *et al.*, 1988) and hydraulic stress (Statzner and Higler, 1986) are in the determination of patterns of benthic distribution, are hard-core questions in fluvial ecosystem theory.

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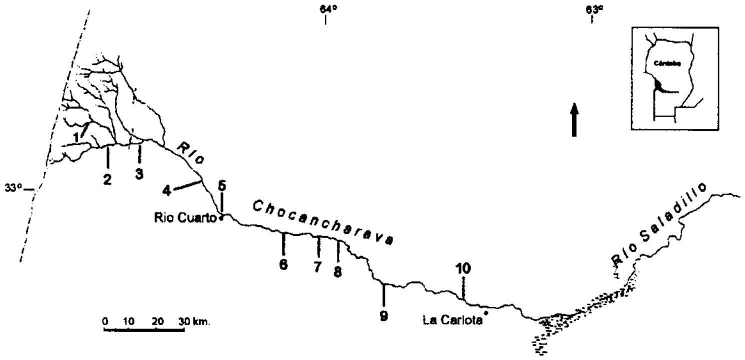

Fig. 1. Location of sampling stations in the Chocancharava river (Córdoba, Argentina).

Table 1. Physico-chemical and environmental characteristics of Chocancharava river. *Dominant sediment size: **3**: > 16 mm; **2**: < 16 > 0.25 mm; **1**: < 0.25 mm.

	Sampling stations									
	1	2	3	4	5	6	7	8	9	10
Altitude (m. asl)	700	618	548	468	433	325	290	260	200	165
Slope (m.km^{-1})	80,6	13,7	7,7	3,3	2,9	3,7	1,8	1,4	1,5	0,9
Width (m)	7	15	17	50	80	50	90	70	60	45
Current velocity (m.s^{-1})	1,26	0,44	0,47	0,55	0,53	0,45	0,45	0,45	0,45	0,35
Depth (cm)	15	30	20	30	20	35	30	35	40	40
Discharge (m^3.seg^{-1})	1,36	2,99	3,56	3,56	3,50	3,50	3,80	3,80	3,80	5,86
Order number	2	5	6	7	7	7	7	7	7	7
Distance from the source (km)	9	35	46	70	82	111	130	151	191	229
Drainage area (km^2)	30	340	1450	1680	1770	1910	2050	2100	2265	2485
Sediment size (mm) *	3	3	2	2	2	2	2	2	1	1
Temperature (°C)	20,9	17,2	18,3	19,1	16,4	14,9	21,0	18,5	16,5	16,4
Termic amplitude (° C)	16,0	18,5	22,0	22,0	23,0	23,0	22,0	22,0	20,0	20,0
pH	8,1	8,4	8,1	8,3	8,3	8,3	8,3	8,3	8,3	8,4
Conductivity at 20 °C (µS.cm^{-1})	105,3	155,9	168,5	237,6	236,1	303,8	308,2	348,7	421,4	526,9
Suspended solids (cm^3)	--	--	0,06	0,12	0,22	0,64	0,65	0,80	0,76	0,85
Dissolved oxygen (mg.l^{-1})	7,40	9,50	8,90	8,40	8,50	9,90	8,40	7,90	8,50	8,80
Redox	20,00	19,52	19,00	19,73	19,50	15,00	18,00	19,80	19,60	19,60
COD (mg.l^{-1})	0,20	0,61	0,70	0,77	1,88	0,78	1,33	1,57	1,99	1,99
Permanganate values (mg.l^{-1})	2,00	3,98	3,00	2,13	2,29	3,16	1,34	2,50	3,00	3,00

The aim of this study has been the spatial characterization and distribution of Ephemeroptera communities in the Chocancharava basin of Córdoba Province as well as its relation to environmental variables.

MATERIALS AND METHODS

Ten sampling sites were selected along the longitudinal gradients of watercourses in Choncancharava river basin (32° 54' - 33° 21' S, 63° 28' - 64° 46' W) (Fig. 1).

Table 2. Density of Ephemeroptera taxa colected from sampling stations of Chocancharava river and number of total taxa by site.

	Sampling stations									
TAXA	1	2	3	4	5	6	7	8	9	10
Baetis sp. 1	147	8166	8071	4643	2331	338	121	179	274	100
Baetis sp. 2	0	350	2324	144	0	0	87	0	0	0
Baetodes sp.	1	1	13	0	0	0	0	0	0	0
Camelobaetidius penai	59	2476	1526	39	8	0	0	0	0	0
Paracloeodes sp. 1	0	0	903	3237	7499	734	829	123	5	5
Baetidae sp.	0	0	0	0	0	0	0	0	11	14
Caenis sp.	26	12	413	8	10	1	0	1	1	3
Leptohyphes sp. 1	907	12883	10346	280	6	0	0	0	0	0
Leptohyphes sp. 2	0	0	0	0	0	0	50	17	13	29
Tricorythodes sp.	32	1235	2340	171	10	0	1	0	0	1
Farrodes sp.	1	75	115	0	0	1	0	1	0	0
Traverella (Zonda) sp.	0	0	0	0	0	0	0	0	0	1
Homoeoneuria sp.	0	0	0	0	0	0	0	10	32	15
Polymitarcyidae sp.	0	0	0	0	0	0	0	0	7	0
Taxa/station	7	8	9	7	6	4	5	6	7	8

Headwaters are located in Sierras de los Comechingones at 2300 m. asl. Study sites were located from 700 to 165 m. asl, where there are second order streams to seventh order lowland collectors (Table 1). Periphyton assemblages are well developed year round and massive growth of *Cladophora glomerata* mats was observed during spring season in foothill stretch (Corigliano *et al.*, 1994). Native insectivore fishes belongs to Characidae and Loricariidae species, and rainbow trout *Onchorynchus mykiss* was introduced in mountain streams. Macroinvertebrates were collected in lotic habitats with a D frame handnet, with a mesh size of 300 m. The sampling period in each site lasted 10 minutes. The sampling program was developed for two years. Sites were visited twice each year during low flow and high flow conditions. A physicochemical water characterization was carried out at sampling sites. The organisms were counted under dissecting microscope and abundance was expressed in ind.10’ which allows quantitative comparisons. From the

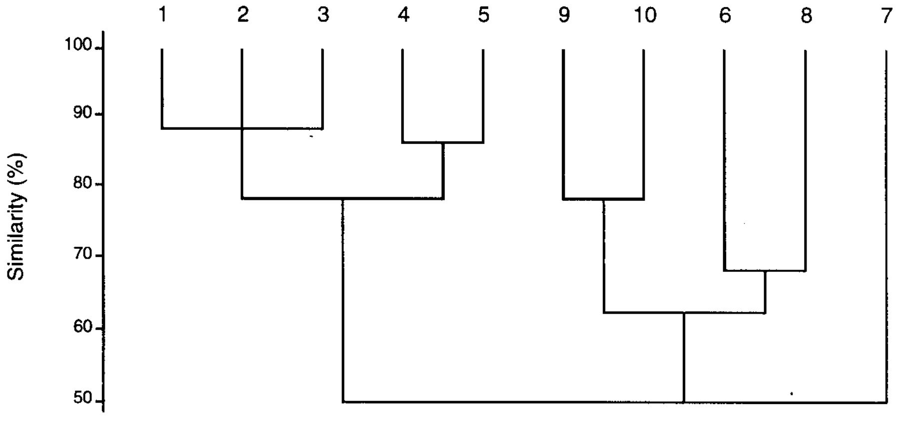

Fig. 2. Percentage similarity between sampling sites based on Ephemeroptera data.

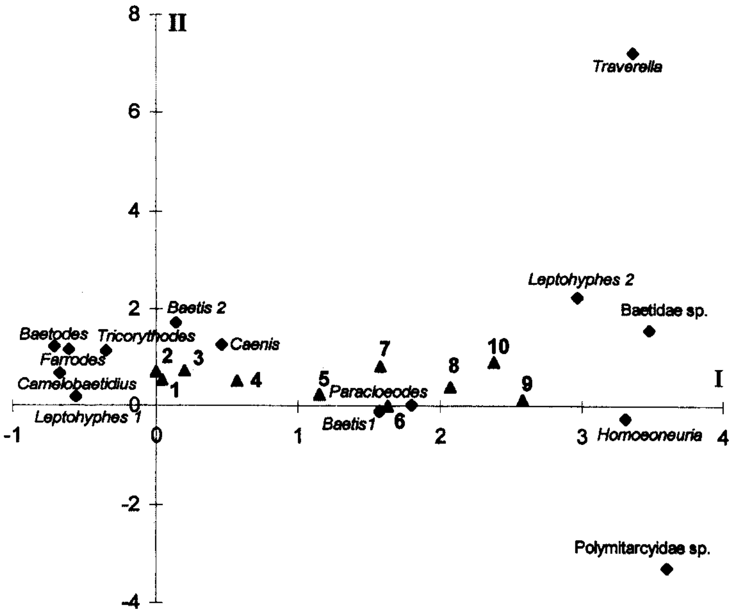

Fig. 3. DCA ordenation diagram (axis I and II) with sampling sites (▲) and Ephemeroptera taxa (◆).

abundance values of Ephemeroptera species the sample average was calculated for each site and with the arithmetic means a data matrix was created. Percentage similarity index was calculated by Jaccard coefficient. Species and sample ordination was performed by means of detrended correspondence analysis, DCA, by DECORANA (Hill, 1979). Pearson linear correlation between environmental parameters and sample scores of DCA axis and organism abundance (log x +1 transformed) were performed.

RESULTS

Fourteen species of Ephemeroptera belonging to six families (Baetidae, Caenidae, Leptohyphidae, Leptophlebiidae, Oligoneuriidae, Polymitarcyidae) were collected. (Table 2). Higher species richness was found at foothill stretches, and sites with lower richness were sampling stations 6, 7 and 8, where the river was recuperating from heavy sewage pollution. The percentage similarity matrix showed that the highest fauna similarity was between adjacent site pairs and there was also an indication of distinct rhithron and potamon assemblages (Fig. 2). Stations 6, 7 and 8 altered the longitudinal sequences of adjacent site pairs and were more dissimilar than the rest.

Arithmetic means of four samples for each site were calculated and DECORANA ordination analysis was performed in ten sample means. Samples and species were arranged in 4 axes whose eingenvalues were: 0.524, 0.049, 0.011 and 0.002. Figure 3 shows the ordination with respect to axes I and II.

The first DCA axis was positively correlated with depth, conductivity, COD, and negatively correlated with altitude and sediment size (Table 3). Higher scores for axis I belonged to Baetidae sp., *Leptohyphes* sp. 2, *Traverella* sp., *Homoeoneuria* sp. and Polymitarcyidae sp., which was the species assemblage from lowland stretches of the river.

Table 3. Linear correlations (r) of environmental parameters with DCA axis. ** = $p < 0.01$; *** = $p < 0.001$.

Parameters	AX1	AX2	AX3	AX4
Altitude (m. asl)	-0,964 ***	0,132	-0,360	-0,324
Slope (m.km^{-1})	-0,543	0,080	-0,557	-0,543
Width (m)	0,699 **	0,714 **	0,148	0,090
Current velocity (m.s^{-1})	-0,514	-0,210	-0,612 **	-0,614
Depth (cm)	0,757 ***	-0,145	0,580	0,577
Discharge (m^3.seg^{-1})	0,693 **	-0,165	0,317	0,329
Order number	0,663 **	-0,191	0,439	0,409
Distance from the source (km)	0,943 ***	0,008	0,324	0,300
Drainage area (km^2)	0,865 ***	-0,147	0,310	0,269
Sediment size (mm)	-0,848 ***	0,116	-0,202	-0,161
Temperature (°C)	-0,329	0,316	-0,092	-0,100
Termic amplitude (° C)	0,347	-0,294	0,238	0,208
pH	0,467	0,029	0,337	0,366
Conductivity at 20 °C (µS.cm^{-1})	0,920 ***	0,024	0,286	0,269
Suspended solids (cm^3)	0,942 ***	-0,103	0,357	0,326
Dissolved oxygen (mg.l^{-1})	0,060	-0,250	0,181	0,219
Redox	-0,230	0,579	0,079	0,080
COD (mg.l^{-1})	0,823 ***	-0,068	0,201	0,158
Permanganate values (mg.l^{-1})	-0,139	0,131	0,355	0,401

Baetodes sp., *Camelobaetidius penai, Farrodes* sp., *Leptohyphes* sp. 1 and *Tricorythodes* sp. had the lowest score for axis I. This group of species characterized the mountain and foothill stretches. *Baetis* sp. 1, *Paracloeodes* ? sp. and *Caenis* sp. were euryzonic and ubiquitous.

Ephemeroptera community had different abundance distribution along the altitudinal gradient (Fig. 4). Major abundance was that of rhithron population, meanwhile *Paracloeodes* ? sp. peaked at potamon. Trends between abundance and environmental parameters were significant for altitude ($r = 0.71$, $p<0.01$), profundity ($r = -0.57$, $p<0.05$), headwater distance ($r = -0.76$, $p<0.01$), sediment size ($r = 0.56$, $p<0.05$), conductivity ($r = -0.74$, $p<0.01$) and COD ($r = -0.48$, $p<0.05$).

DISCUSSION

Community structure of Ephemeroptera was affected by environmental factors which depends on gradients of altitude. There is a gradual change in abundance downstream and a substitution of species along the elevation gradients from foothill to lowland river. A major discontinuity was observed under conditions of environmental stress, as pollution and hydraulic shifts.

Since the development of the concept of rhithron and potamon (Illies et Botosaneanu, 1963) and the River Continuum Concept (Vannote *et al.*, 1980) a lot of work has been carried out in order to answer the question of whether species distribution is clinal or zonal. Changes in abundance patterns of Ephemeroptera species along altitudinal gradients have been reported under different environmental lotic conditions (Gonzalez *et al.*, 1985; Dudgeon, 1990; Ward and Berner, 1980; Ward and Stanford, 1990; Domínguez and Ballesteros Valdez, 1992). Ward (1986), dealing with rivers whose lower basin are at high

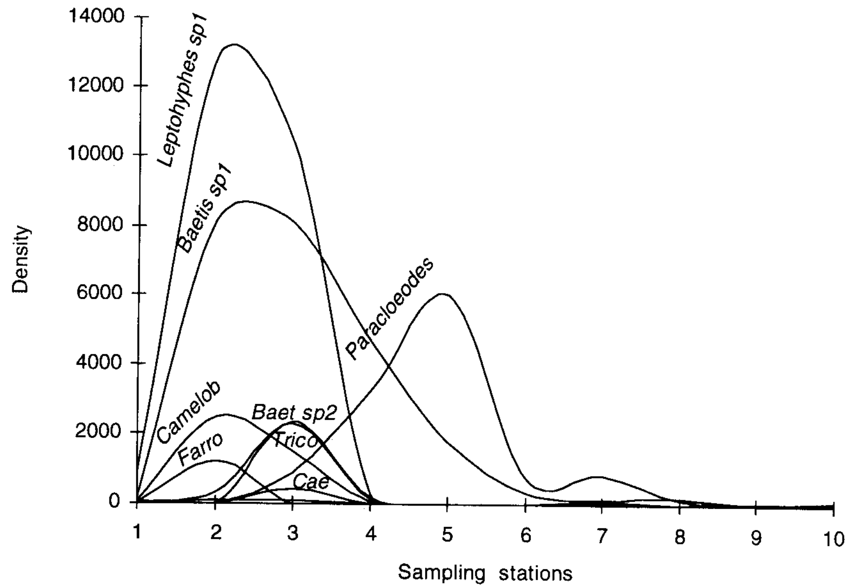

Fig. 4. Spatial distribution of the Ephemeroptera taxa along the longitudinal profile of Chocancharava river.

elevation plains, stated that the general pattern was the addition of species downstream without loss of those present in higher elevations. Gonzalez *et al.*, (1985) reported differences among the distribution pattern of five zonal groups overlapping from upper reaches to lower zones.

At Chocancharava river basin longitudinal profile is heterogeneous. Hierarchical structure is composed by short length streams in upper catchment area and a longer collector in lowland floodplain. Potamon reaches present different geomorphologic channel patterns: braided, anastomosing, meandering and straight. There is a loss of mountain species as one passes from rhithron to potamon conditions and there is a discontinuous addition of species downstream. Middle order streams have higher species richness in agreement with prediction of Vannote *et al.*, (1980). *Baetis* sp. 1 and *Caenis* sp. are euryzonal; *Baetis* sp. 2, *Camelobaetidius penai*, *Farrodes* sp. and *Baetodes* sp. are restricted to mountain streams. Some individuals of these species were found in lowland river but this fact is interpreted by drift phenomenon (Allan, 1995). Stenozonal lowland species were *Traverella* sp., *Homoeoneuria* sp. and Polymitarcyidae sp.

Although water temperature is reported as one of the most important factors affecting altitudinal zonation (Ward, 1992) we do not find correlation between temperature and DCA ordination axis, maybe because the study area is under more or less homogeneous climate conditions. Other physical-chemical variables indicative of water quality, such as COD and conductivity, were negatively correlated with Ephemeroptera abundance. Dudgeon (1990) found that pollution-related parameters were the major predictors of mayfly abundance in anthropic impacted running waters. In Chocancharava river basin good quality water conditions of rhithron allows the development of a mayfly community indicative of the ecological integrity of lotic systems. Other factors determining abundance distribution patterns such as predation, competition and disturbance must be interacting with the gradient of environmental stress (Mengue and Sutherland, 1987).

Hydraulic stress (Statzner and Higler, 1986), different combinations of geomorphological patterns and substrate size determinate habitat structure changes and longitudinal boundaries (Naiman *et al.*, 1988). Another environmental stress affecting the discontinuity of the distributions, is sewage effluent from Río Cuarto city (160,000 habitants). The hydraulic shift to potamon conditions is almost simultaneous with the entry of polluted effluents. The simultaneity of these two events affects synergically the composition of lowland communities. Some species do not pass through the hydrological barriers and others do not pass the pollution barriers.

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